AD NUMBER
AD311199
CLASSIFICATION CHANGES
TO: unclassified
FROM: confidential
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Controlling DoD Organization: U.S. Army Electronic Proving Ground, Electronic Warfare Dept., Fort Huachuca, AZ.
AUTHORITY
Army Electronic Proving Ground ltr dtd 10 Jan 1980; Army Electronic Proving Ground ltr dtd 10 Jan 1980

AD NUMBER
AD311199
CLASSIFICATION CHANGES
TO confidential
FROM secret
AUTHORITY
28 Feb 1969 per Group-3, DoDD 5200.10 document marking

AD 311199

DEFENSE DOCUMENTATION CENTER

FOR

SCIENTIFIC AND TECHNICAL INFORMATION

CAMERON STATION, ALEXANDRIA, VIRGINIA

SECRET

AEPG-SIG 920-77

F[redacted]T, OPERATIONAL EVALUATION

OF

ELECTRONIC COUNTERMEASURES SET AN/MLQ-8(XL-1) ~~(U)~~

EW SYSTEMS TEST

USAEPG-3

PHASE II,

EQUIPMENT TEST

AND EVALUATION

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USAEPG-SIG 920-77, Job 33-56-0013, "Final Report, Operational Evaluation of Electronic Countermeasures Set AN/MLQ-8(XL-1)" (U), has been prepared by the Electronic Warfare Department for the information of all concerned. Suggestions or criticisms on the form, contents, or use thereof, are invited, and recommendations may be submitted to the Commanding General, United States Army Electronic Proving Ground, Fort Hauchuca, Arizona, ATTN: SIGPG-DCGO.

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Errata USAEPG-SIG 920-77

page 11. In second paragraph of "Background," "T-226-E9" should be changed to "T-226E2A."

page 64. Heading of Table XXIV. Second line should read "0-Degree Aspect."

FINAL REPORT
OPERATIONAL EVALUATION OF ELECTRONIC COUNTERMEASURES SET AN/MLQ-8(XL-1) (U)
(Job 33-56-0013)

February 1957

Electronic Warfare Department
UNITED STATES ARMY ELECTRONIC PROVING GROUND
Fort Huachuca, Arizona

- - -

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Contract No. DA-36-039-sc-67463

FOREWORD

This final report on the operational evaluation of Electronic Countermeasures Set AN/MLQ-8(XL-1) was prepared by the Electronic Warfare Department as a part of Job 33-56-0013 (USAEPG-3 EW Systems Test) of the United States Army Electronic Proving Ground Technical Program. The report is based on field tests, including firing tests, conducted at Fort Huachuca, Arizona, during the periods March through August, 1955, and March and April, 1956.

Artillery support for the firing tests was furnished by C Battery, 294th Field Artillery Battalion, Fort Bliss, Texas, and the Flash Ranging Platoon of B Battery, 617th Field Artillery Observation Battalion, Fort Sill, Oklahoma. The 2d Platoon of the Heavy Mortar Company, 5th Infantry Regiment, Fort Lewis, Washington, provided support for the mortar firing tests. Personnel of the 1st Signal Group, Fort Huachuca, participated in operating and maintaining the various equipments.

Tests in this report do not necessarily correspond to those contained in the test plan issued for the task. Some tests in the original test plan were not performed because basic engineering data required were obtained from other reliable sources. Certain other tests were modified, deleted, or expanded to attain the basic objectives through different approaches, and a few tests were deferred and later completed during autumn of 1956.

H. McD. BROWN
Col SigC
Chief, Electronic Warfare Department

ABSTRACT

Results of an operational evaluation of Electronic Countermeasures Set AN/MLQ-8(XL-1) are set forth. The AN/MLQ-8(XL-1) is a truck-mounted, swept-repeater jammer for predetonating artillery VT fuzes in the frequency band of 110 to 170 Mc/s.

Optimum operating parameters for the jammer were determined.

The capability of the AN/MLQ-8(XL-1) to predetonate normal VT (NVT) fuzes of the T-226 type was satisfactorily demonstrated at an extreme range of 15,000 yards for high-angle fire and 10,500 yards for low-angle fire, both under optimum conditions for the jammer (including 90-degree aspect).

Use of the controlled (CVT) feature of the fuzes so that they arm 3 seconds before impact reduced the maximum ranges approximately 50 ~~percent.~~ %. The jammer was tested under a number of adverse conditions which were found to reduce its effectiveness by from 20 to 90 ~~percent.~~ %.

From the results of the tests it was estimated that two jammers, properly sited and adjusted, placed 5,000 yards apart behind a substantially straight main line of resistance, can protect an area of about 6 square miles from CVT- and NVT-fuzed fire.

CONTENTS

CONTENTS (Cont)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Cont)

LIST OF TABLES

LIST OF TABLES (Cont)

Section I. Summary

Operational field tests were performed on Electronic Countermeasures Set AN/MLQ-8(XL-1) to evaluate operating parameters, range and effectiveness, and vulnerabilities to intentional and nonintentional interference. The equipment satisfactorily predetonated VT fuzes of the T-226 type.

The operating parameters of the jammer were the subject of the first group of tests. The optimum settings were found to be as follows:

1. Sweep rate: 1.5 sweeps per second (high-angle fire)
   2.0 sweeps per second (low-angle fire)
2. Pulse width and delay time: 2.4 microseconds
3. Duty cycle: 1/3
4. Power output: maximum
5. Antenna polarization: 0 degrees for NVT fuzes, 45 degrees for high-angle CVT fuzes
6. Antenna elevation: 10 degrees

The maximum effective range was greatest for 90-degree aspect (15,000 yards against high-angle fire and 10,500 yards against low-angle fire) when the jammer was used against NVT fuzes, and in the absence of obstructions or other interferences including enemy counter-countermeasures.

The maximum effective range was reduced when the aspect, antenna elevation, or antenna polarization was changed or when CVT fuzes were used. The maximum ranges against CVT fuzes were 8,250 yards for high-angle fire and 5,250 yards for low-angle fire. The jammer's effectiveness was reduced against fire from 0-degree aspect to 1,000 yards against low-angle fire.

From a tactical standpoint, the area over which the jamming is effective against CVT fuzes (the most difficult to predetonate) is a corridor of 2,000 by 5,000 yards, approximately 3 square miles. If enemy fire comes from a 180-degree sector, this area is doubled since the screening effect of the active predetonation area gives protection to at least a comparable area to the rear; thus the total area protected may be 6 square miles.

Volley fire, producing signals appearing simultaneously within the pass band of the jammer, causes the power to be shared and reduces the effective range by a factor equal to the reciprocal of the square root of the number of simultaneous signals.

When trees or vegetation interfere between the jammer and shell trajectories, the effective range is reduced by about 25 percent. The presence of reflecting hills behind the shell trajectory reduces the effective range by 50 percent.

Friendly NVT shells were predetonated when passing through the antenna field of the jammer; furthermore, they reduced the effective range against enemy shells by power-sharing the jammer output. Friendly CVT fuzes, arming beyond the jammer field, do not cause this problem.

Interfering signals, if not sweeping, can cause reduction in effective range by the principle of power-sharing. Radiating 1,000 watts of interfering signal directly into the jammer beam from a distance of 7,000 yards reduced the effective range by 50 percent.

A subsequent modification of the AN/MLQ-8(XL-1), the (XL-2), although miniaturized and more rugged, was found to possess about 30 percent less effective range than the (XL-1). For a comparison of the two equipments, see Annex C.

Section II. Introduction

1. BACKGROUND

Electronic Countermeasures Set AN/MLQ-8(XL-1) is an experimental jammer unit designed by the University of Michigan. A prototype model was built and tested by Signal Corps Engineering Laboratories (SCEL) at Fort Dix, New Jersey, in April 1954. It predetonated VT fuzes successfully. Subsequently the Electronic Defense Laboratory (EDL), Mountain View, California, built four models under Contract DA 36-039-sc-31435 which were used in tests at USAEPG during the period of September to December 1954, where they predetonated 1099 of 1120 rounds. Further tests were conducted by SCEL at Ft. Sill, Oklahoma, during March and April 1955, but the results obtained were not considered conclusive, and additional tests were recommended. They are the subject of this report.

The jammer was designed to predetonate T-226 VT fuzes and their several modifications, including T-226-E9, which is equipped with an antijamming circuit which required the received signal to be present for a fixed minimum time before the fuze will detonate the round.

This jammer will not deny the enemy the use of artillery shells which are time detonated in the air at an altitude for maximum destruction. It does force an enemy either to calculate the time of flight for each round and then mechanically set the fuzes or to design elaborate antijamming circuits that will protect electronic fuses against jamming.

The AN/MLQ-8(XL-1) has since been further developed into a tactical jeep-mounted model, AN/MLQ-8(XL-2), which is provided with a squelch circuit because the (XL-1) transmits a significant noise signal during periods when no fuze is being jammed.

2. PURPOSE

The purpose of these tests was to evaluate the operating characteristics of the AN/MLQ-8(XL-1), to determine its range and effectiveness, and to ascertain the influence of terrain and enemy counter-countermeasures.

Section III. Description of Electronic Countermeasures Set AN/MLQ-8(XL-1)

3. GENERAL

Electronic Countermeasures Set AN/MLQ-8(XL-1) is a swept-repeater jammer used to predetonate VT fuzes in the frequency band of 110-170 Mc/s.

4. FUNCTIONAL DESCRIPTION

The AN/MLQ-8(XL-1) receives and transmits using the same antenna on a time-sharing basis. The general operation of the repeater can be understood by referring to the block diagram, fig. 1. Incoming signals pass through the distributed amplifier nr 2 and without amplification reach the receiver mixer. The local oscillator is continuously swept through the range from 310 to 370 Mc/s, and as it scans the band, a 200 Mc/s component is generated in the mixer whenever a signal 200 Mc/s below the instantaneous oscillator frequency is present in the band. This 200 Mc/s signal is fed to the if. preamplifier and if. amplifier, which pass and amplify signals in the range from 195 to 205 Mc/s. An attenuator permits the signal level to be adjusted, and a coaxial line delays the signal about 2 usec. The gated if. amplifier and power if. amplifier pass the signal through network 1 to the power (output) mixer. Since this mixer is also fed with a signal from the local oscillator, one product in its output will be approximately the frequency of the original incoming signal. The difference between the frequency of the received and transmitted signal is due to the time delay introduced by the coaxial delay line and the sweeping action of the local oscillator. If the local oscillator is scanned through its 60 Mc/s range about twice per second, the average frequency change will be about 150 cps/usec or 300 cps for the 2-usec delay time. The sweep rate can be adjusted to give the frequency shift which is most advantageous for a specific operation. From the power (output) mixer the signal passes through network 2-1 to the distributed amplifiers nr 1 and nr 2, which amplify the signal and feed it to the antenna for radiation. Feedback around the loop is prevented by the action of the gated generator and the delay lines.

Some of the parameters mentioned above can be varied:

1. The transmit time or pulse width can be varied from 0.8 to 2.4 usec.

2. The duty cycle can be changed from 1/3 to 1/5.

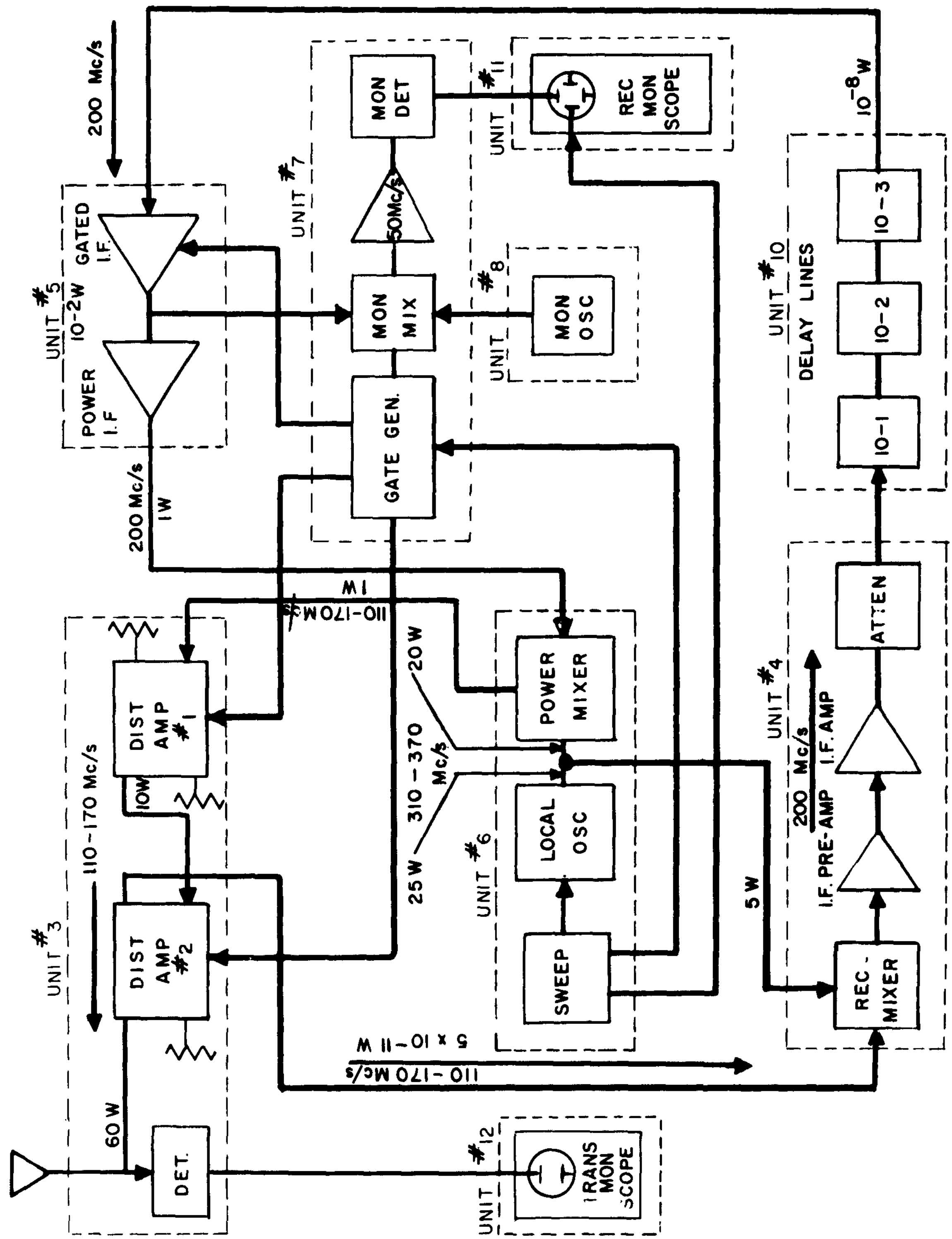

Fig. 1. Block diagram of the AN/MLQ-8(XL-1)

3. The sweep rate can be varied from 0.5 to 4.0 sweeps/sec.

4. The delay time can be varied in steps of 0.8, 1.6, and 2.4 usec.

5. PHYSICAL CHARACTERISTICS

Electronic Countermeasures Set AN/MLQ-8(XL-1) is mounted in a 3/4-ton truck which pulls a trailer containing the power unit. The jammer is made up of 14 components, listed in Table I. Figs. 2 - 7 show main components of the equipment and antennas used in the tests. Antenna AS-542/U was used in all tests reported except Test 7, Antenna Types.

6. TECHNICAL CHARACTERISTICS

Electronic Countermeasures Set AN/MLQ-8(XL-1) is a single-antenna, superheterodyne, swept-repeater jammer operating in the frequency range of 110 to 170 Mc/s. Technical characteristics are:

Frequency Range	110 - 170 Mc/s
If. range	195 - 205 Mc/s
Oscillator frequency range	310 - 370 Mc/s
Bandwidth	6 Mc/s
Sweep rate (variable)	0.5 - 4 sweeps/sec
Range	To be determined by test
Power requirement	5 Kw, 120v, single-phase 60 cps[a]
Antenna	AS-542/U[b]

[a]Or any similar power unit; it is not an integral part of AN/MLQ-8 (XL-1).

[b]This is not the antenna supplied by EDL, but it is the one used throughout most of the testing.

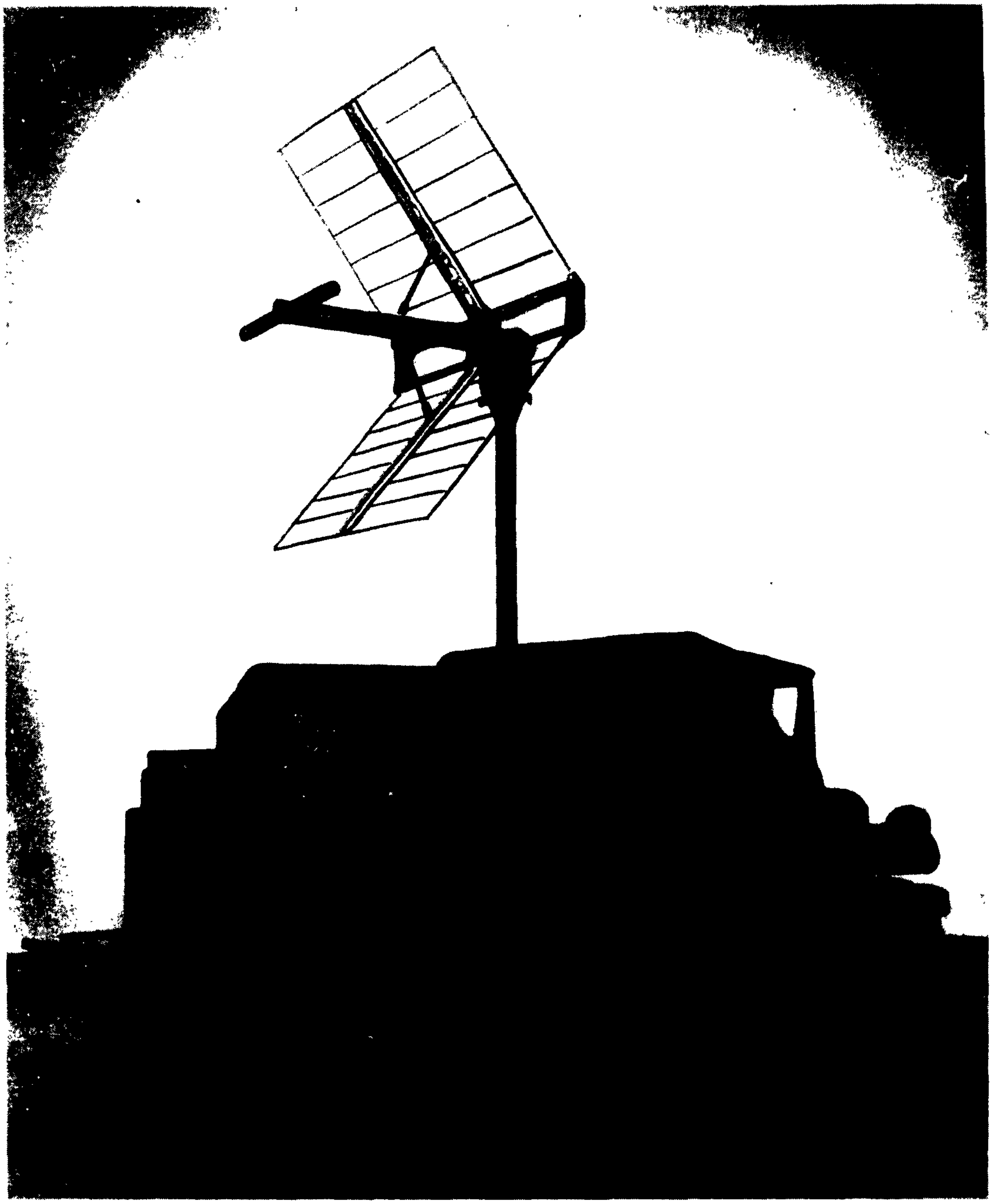

Fig. 2. AN/MLQ-8(XL-1) mounted in 3/4-ton truck M-37, with EDL folded dipole antenna in operating position, horizontal polarization

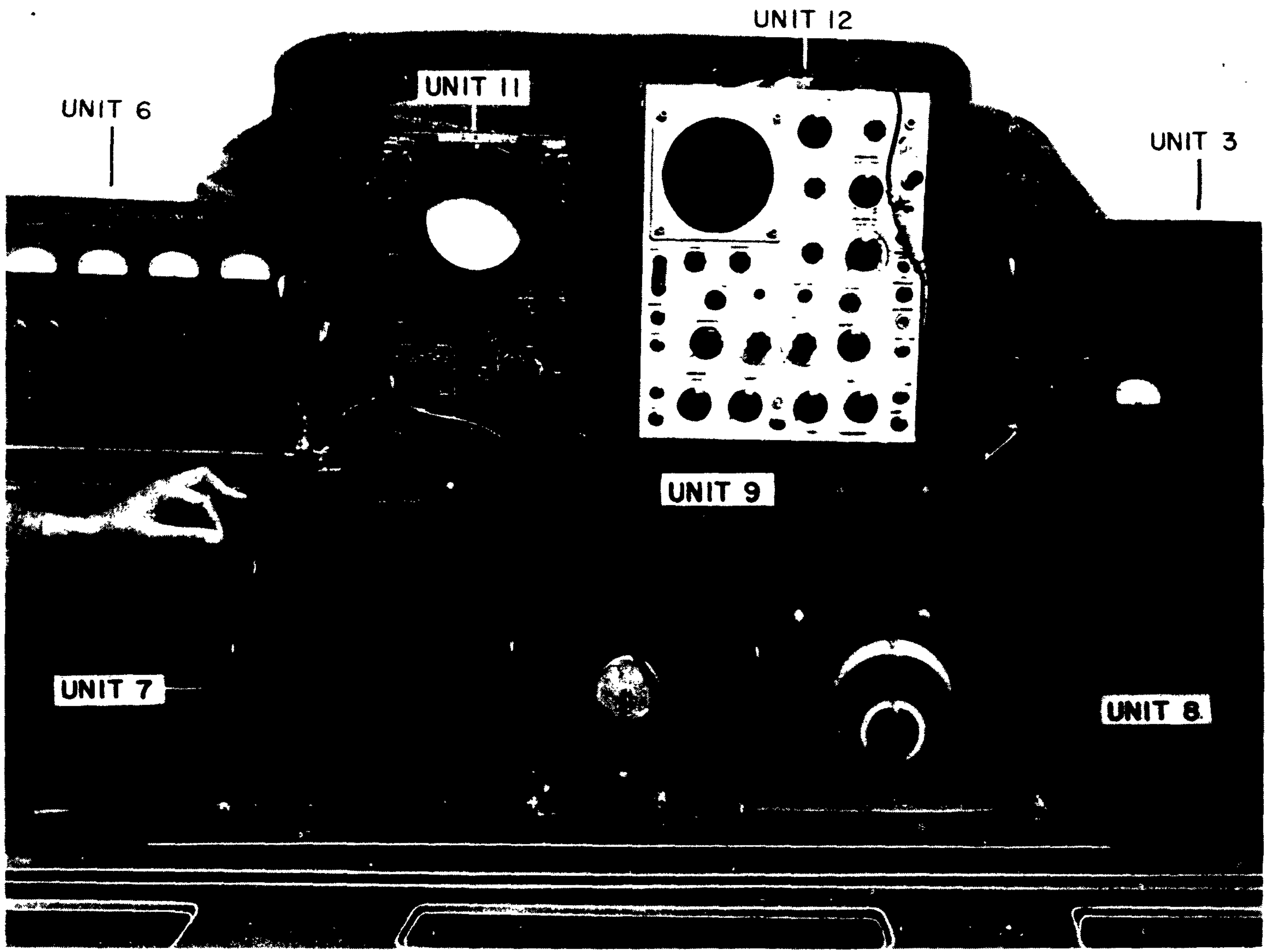

Fig. 3. Main operating components, AN/MLQ-8(XL-1), mounted across rear of truck M-37

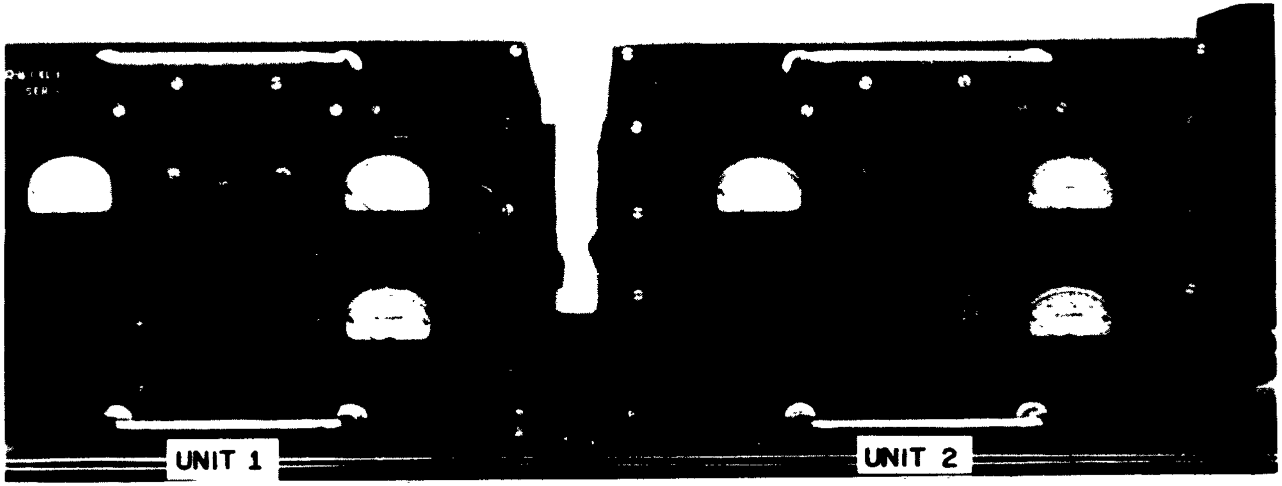

Fig. 4. Distributed amplifier power supply (units 1 and 2) of AN/MLQ-8(XL-1), mounted on left side of truck

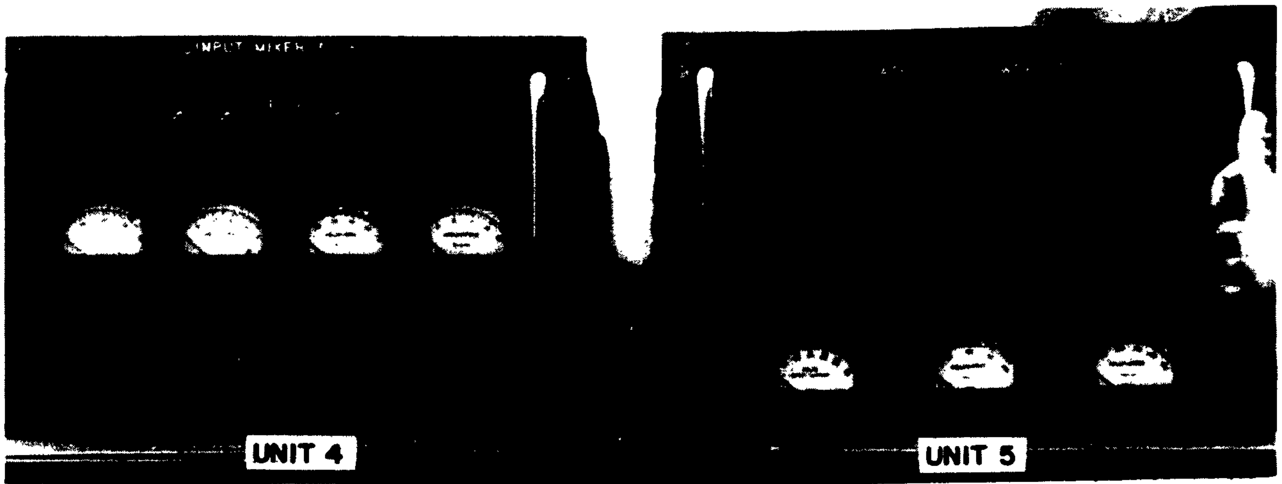

Fig. 5. Input mixer and if., (unit 4) and gated if. —power if. (unit 5) of AN/MLQ-8(XL-1), mounted on right side of truck

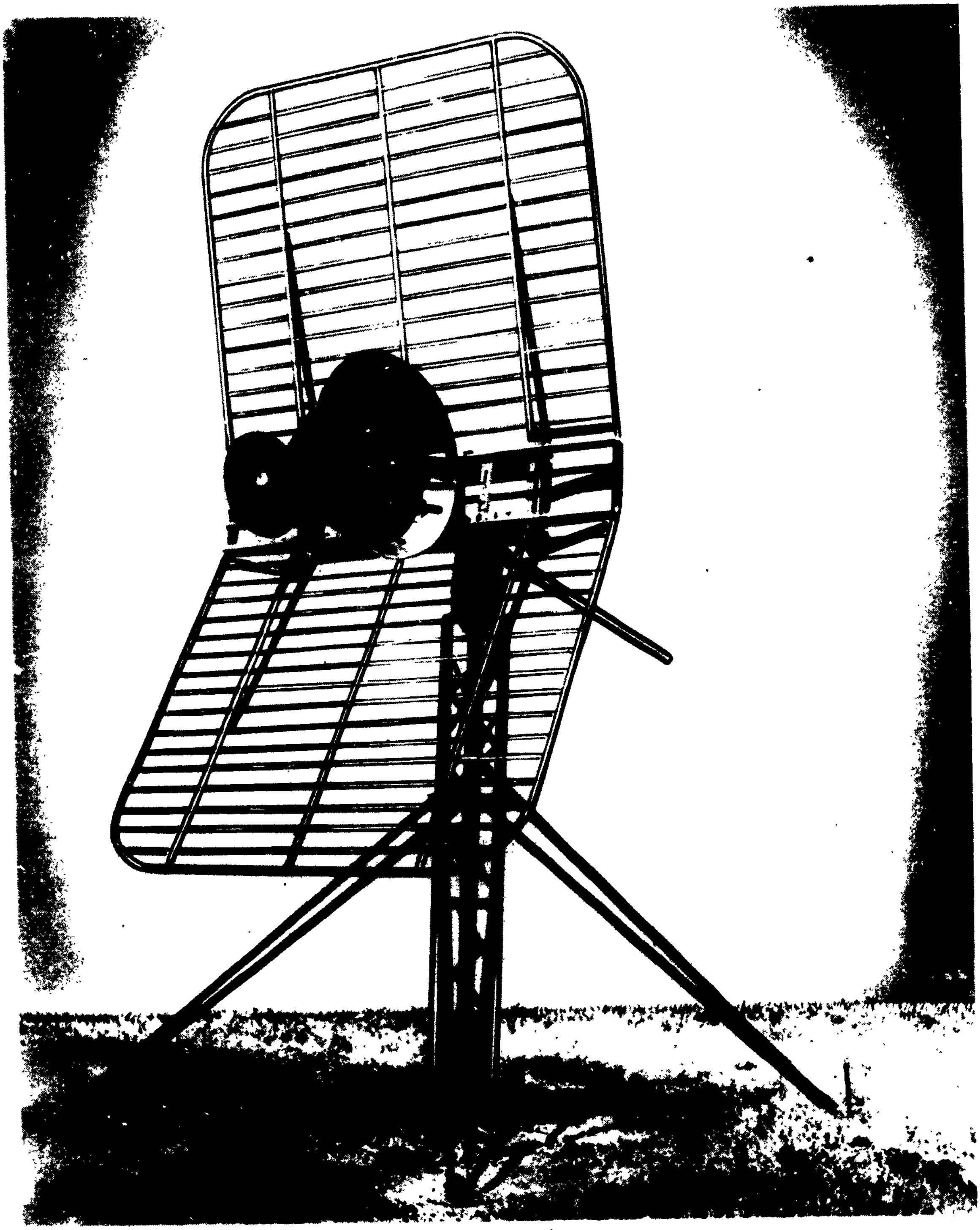

Fig. 6. AS-542/U Antenna

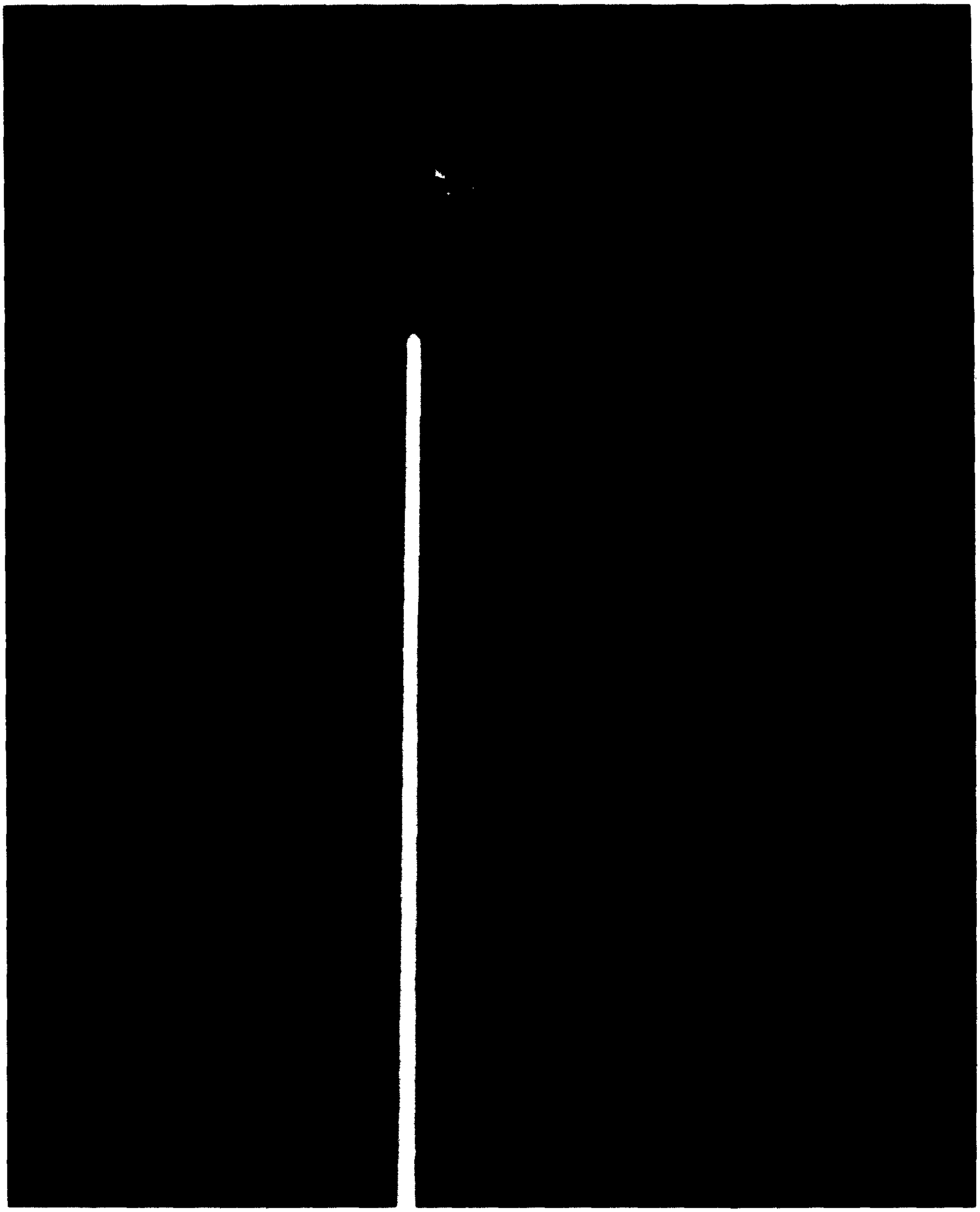

Fig. 7. Telrex X-100 Antenna

Table I. AN/MLQ-8(XL-1) Components, Approximate Volume and Weight

Unit nr	Description	Weight[a] (lbs)	Volume (cu ft)
1	Distributed amplifier power supply	122	2.6
2	Distributed amplifier power supply	122	2.6
3	Distributed amplifiers	88	2.6
4	Input and booster if. amplifiers	79	2.6
5	Gated if. - power if. amplifiers	97	2.6
6	Local oscillator and power mixer	108	2.6
7	Gated generator - monitor	83	2.6
8	Monitor oscillator and control	93	2.6
9 & 10a	Power junction box and delay line 1	124	2.6
10b & 10c	Delay lines 2 and 3	162	2.6
11	Oscilloscope DuMont 304A	86	1.4
12	Oscilloscope, Tektronix Type 514AD	100	3.0
	TOTAL[b]	1264	30.4

[a]Weight estimated by subtracting 10 percent from boxed shipping weights.

[b]Total does not include antenna and supports because figures from EDL are not for Antenna AS-542/U used for most of these tests. Components 13 and 14 are the EDL antenna and its supports.

Section IV. Tests to Determine Optimum Operational Parameters

This group of tests was conducted to determine the optimum operational parameters for the use of the AN/MLQ-8(XL-1).

7. TEST 1. SWEEP RATE

The purpose of this test was to determine what sweep rates of the AN/MLQ-8(XL-1) result in optimum operating characteristics when used against high-angle and low-angle fire. Constant parameters of the test are listed in Table II, and the siting was as shown in fig. 23, Annex A.

Results of the test, as presented in fig. 8 and Table II, indicate that the optimum sweep rates are included within very narrow margins. Although 100-percent kill was never attained during low-angle fire, the results are conclusive. For high-angle fire the most effective sweep rate is 1.5 sweeps/sec, and for low-angle it is 2.0 sweeps/sec.

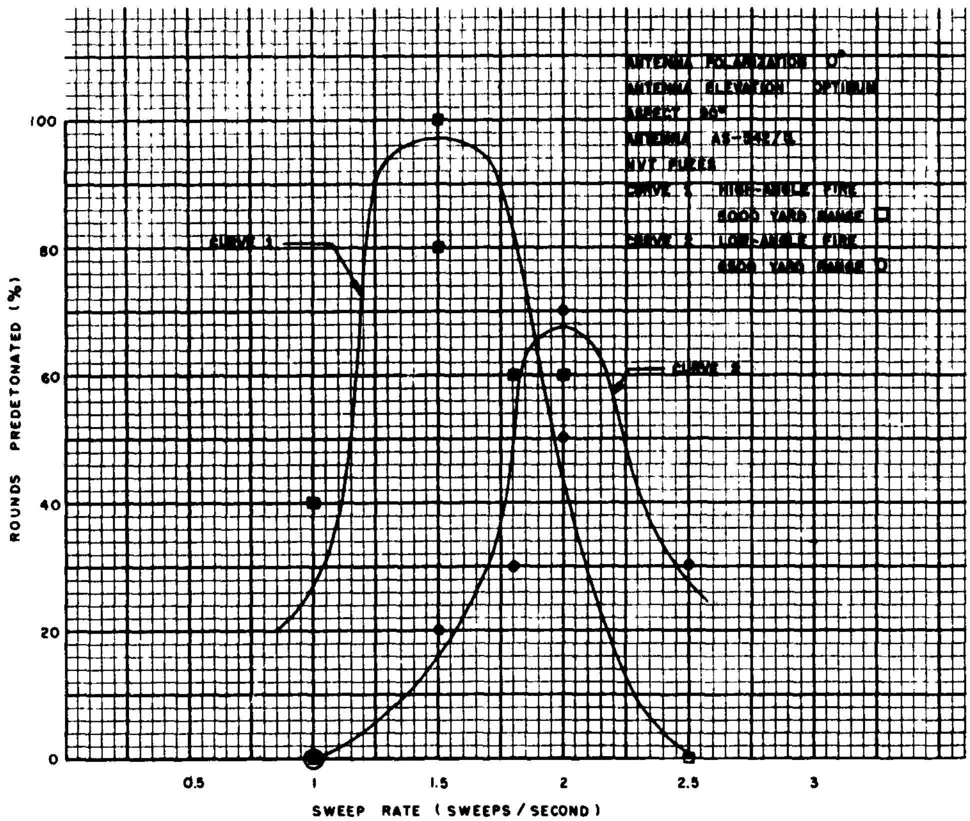

Fig. 8. Percentage of kill, test 1, high- and low-angle fire

Table II. Results of Test to Determine Sweep Rates

Sweep rate (sweeps/sec)	Percentage of rounds predetonated	
	High-angle fire (5,000-yd range)	Low-angle fire (6,500-yd range)
1.0	0	---
1.0	40	0
1.5	80	---
1.5	100	20
1.8	60	30
2.0	---	50
2.0	60	70
2.5	0	30

Parameters

Variable: sweep rate

Constants	Value	Constants	Value
Antenna polarization	0 deg	Delay time	2.4 usec
Antenna elevation	Optimum[a]	Duty cycle	1/3
Attenuation	9 db	Range (jammer to trajectory)	5,000 yds and 6,500 yds
Aspect	90 deg		
Pulse width	2.4 usec	Angle of fire	High-angle, charge 3 Low-angle, charge 4
		Fuzes	NVT (early arming)

[a] See Annex B for definition

8. TEST 2. DUTY CYCLE

The purpose of the test was to determine the optimum duty cycle for use with the AN/MLQ-8(XL-1). The parameters employed and the results attained are shown in Table III. They indicate that duty cycles from 1/4 to 1/3 produce the highest percentage of kills for both high- and low-angle fire. Since a duty cycle of 1/3 gives the higher average power, this cycle is recommended.

The siting arrangements appear in fig. 23, Annex A. To keep the jammer within the confines of the military reservation it was necessary to decrease the maximum effective range by desensitizing the jammer.

Table III. Results of Test to Determine Optimum Duty Cycle

Angle of fire	Duty cycle	Range (yds)	Percentage of rounds predetonated
High	1/2	5,000	20
High	1/2	4,500	0
High	1/2	4,000	0
High	1/3	5,000	90
High	1/3	4,500	100
High	1/3	4,000	100
High	1/4	5,000	90
High	1/4	4,500	100
High	1/4	4,000	100
Low	1/2	6,300	0
Low	1/2	5,800	0
Low	1/3	6,300	20
Low	1/3	5,800	80
Low	1/3	5,000	70
Low	1/4	6,300	0
Low	1/4	5,800	80

Parameters

Variables: range and duty cycle

Constant	Value	Constant	Value
Antenna polarization	0 deg	Pulse width	2.4 usec
Antenna elevation	Optimum	Delay time	2.4 usec
Attenuation	-9 db	Angle of fire	High, charge 3 Low, charge 4
Aspect	90 deg	Fuzes	NVT (early arming)
Sweep rate	1.5 sweeps/sec (high-angle fire 2.0 sweeps/sec (low-angle fire		

9. TESTS 3 AND 4. PULSE WIDTH AND DELAY TIME

The purpose of these tests was to determine optimum pulse width and delay time for operation of the AN/MLQ-8(XL-1). The pulse width and delay time were kept equal to each other because it is very desirable to transmit all of the signal through the delay line.

The delay time was varied by connecting different lengths of coaxial cable, three 500-ft spools of which are included with the jammer, to provide delay times of 0.8, 1.6, and 2.4 usec. It was found that the AN/MLQ-8(XL-1) was erratic and suffered from reduced output when it used 0.8 usec delay time; tests were therefore conducted only on delay times of 1.6 and 2.4 usec.

The siting arrangements are shown in fig. 23 of Annex A. Parameters of the test and results appear in fig. 9 and Table IV, which shows that the highest available pulse width and corresponding delay time, 2.4 usec, yielded the most effective results.

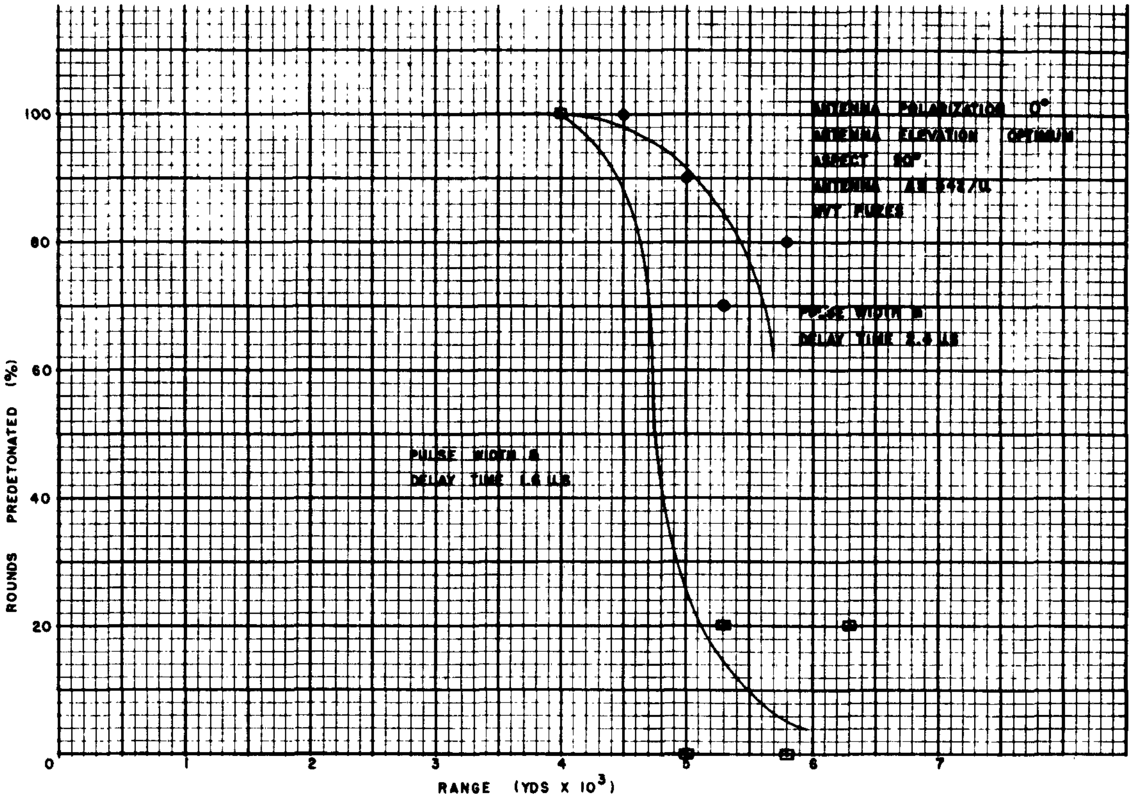

Fig. 9. Percentage of kill as a function of range for two different pulse widths and delay times, tests 3 and 4

Table IV. Results of Tests to Determine Optimum Pulse Width and Delay Time

Pulse width (usec)	Delay time (usec)	Range (yds)	Percentage of rounds predetonated
1.6	1.6	4,000	100
1.6	1.6	5,000	0
1.6	1.6	5,300	20
1.6	1.6	5,800	0
1.6	1.6	6,300	20
2.4	2.4	4,500	100
2.4	2.4	5,000	90
2.4	2.4	5,300	70
2.4	2.4	5,800	80

Parameters

Variables: range, pulse width, and delay time

Constants	Value	Constants	Value
Antenna polarization	0 deg	Sweep rate	1.5 sweeps/sec
Antenna elevation	Optimum	Duty cycle	1/3
Attenuation	-27 db (1.6 usec delay) -9 db (2.4 usec delay)	Angle of fire Fuzes	High, charge 3 NVT
Aspect	90 deg		

10. TEST 5. ANTENNA POLARIZATION

The purpose of the test was to determine the optimum polarization of Antenna AS-542/U when employed with the AN/MLQ-8(XL-1). Two polarizations were investigated, 0 degrees and 45 degrees, because these provide optimum coupling at the mid-point and the terminal portion of the trajectory of the projectile. Siting arrangements are shown in fig. 23, Annex A.

The test showed that the horizontal polarization (0 degrees) gives about 40 percent greater range than 45-degree polarization with optimum antenna elevation and at 90-degree aspect against either NVT or CVT fuzes. The parameters and results are shown in Table V.

Table V. Results of Test to Determine Optimum Antenna Polarization

Angle of fire	Attenuation (- db)	Antenna polarization (deg)	Maximum[a] effective range (yds)
High	9	0	4,900
High	4	0	5,500
High	1	0	7,100
High	9	45	3,450
High	4	45	3,900
High	1	45	5,200
Low	9	0	6,000
Low	4	0	6,200
Low	1	0	6,900
Low	9	45	3,450
Low	4	45	3,900
Low	1	45	5,200

Parameters

Variables: antenna polarization, attenuation, and range

Constants	Value	Constants	Value
Antenna elevation	Optimum	Delay time	2.4 usec
Aspect	90 deg	Duty cycle	1/3
Sweep rate	1.8 sweeps/ sec	Angle of fire	High, charge 3 Low, charge 4
Pulse length	2.4 usec		

[a] See definition of maximum effective range in Annex B.

11. TEST 6. POWER OUTPUT

The purpose of the test was to determine the power output of the AN/MLQ-8(XL-1) in terms of maximum effective range. The siting arrangements appear in fig. 23, Annex A. The parameters employed are shown in Table VI. The results, given in the same table, show that as power is increased, maximum effective range also increases.

Table VI. Results of Test to Determine Relation of Power Output to Maximum Effective Range

Attenuation (- db)	Distributed amplifiers in circuit (nr)	Maximum effective range (yds)
9	2	5,200
12	2	4,800
9	1	4,100
12	1	3,700

Parameters

Variables: range and power output

Constants	Value	Constants	Value
Antenna polarization	0 deg	Pulse width	2.4 usec
Antenna elevation	Optimum	Delay time	2.4 usec
Attenuation	-9 db and -12 db	Duty cycle	1/3
Aspect	90 deg	Angle of fire	Low, charge 4
Sweep rate	2.0 sweeps/sec	Fuzes	NVT

12. TEST 7. ANTENNA TYPES

The objective of the test was to determine the optimum type of antenna for use with the AN/MLQ-8(XL-1). For this test the gain of the jammer was reduced so that excessive ranges would not make it necessary to site the jammer outside the boundaries of the Fort Huachuca Military Reservation. The siting arrangements are shown in fig. 23, Annex A.

Antenna AS-542/U and the EDL folded dipole were both field-tested in terms of range. The results, shown in fig. 10 and in Table VII, show that the AS-542/U is superior to the EDL folded dipole for use with the AN/MLQ-8(XL-1). Other tests have previously shown that the AS-542/U is also superior to the Telrex X-100 antenna for use with this particular jammer. For tactical use the large AS-542/U may, at times, be unsuitable, but it does have greater gain, and the effect of lobing because of terrain reflections is less pronounced with the AS-542/U than with other types.

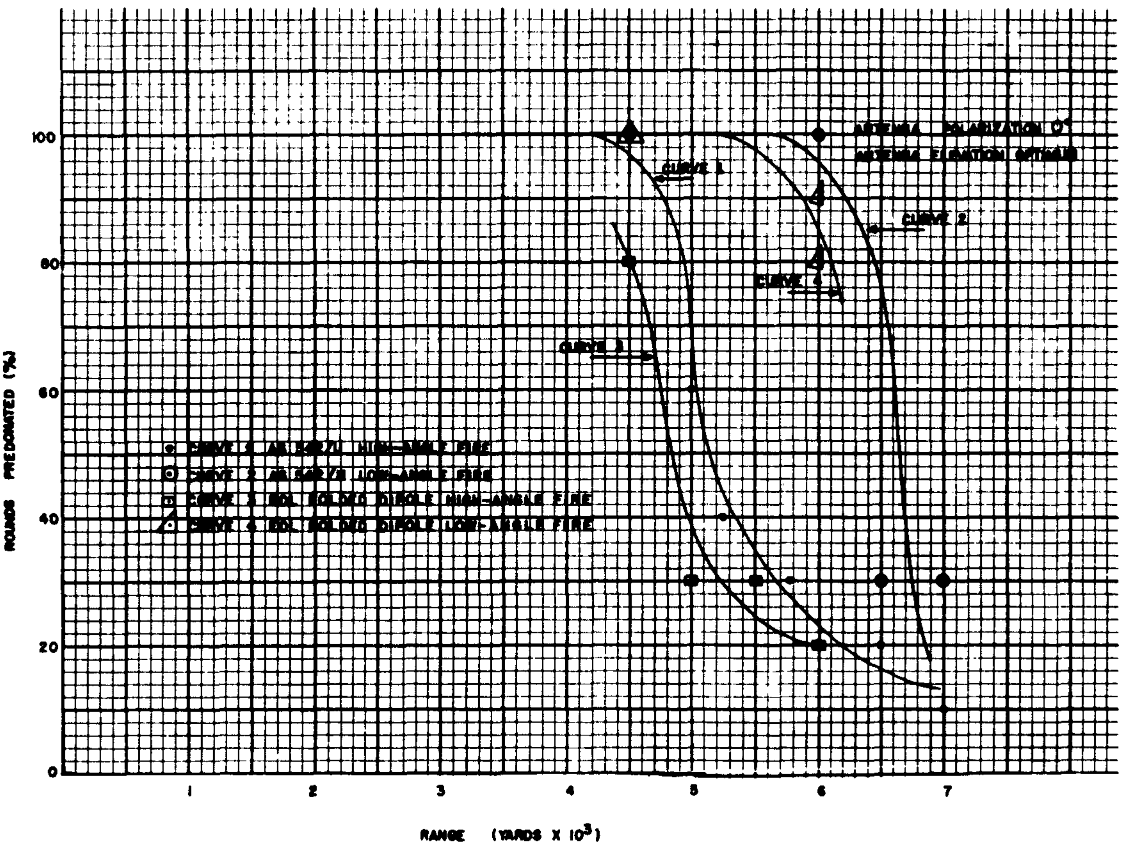

Fig. 10. Percentage of kill as a function of range for different antennas, test 7

Table VII. Results of Test to Determine Optimum Type of Antenna

Range (yds)	Percentage of rounds predetonated			
	Low-angle fire		High-angle fire	
	AS-542/U	EDL folded dipole	AS-542/U	EDL folded dipole
4,500	100	100	100	80
5,000	---	---	60	30
5,250	---	---	40	---
5,500	---	---	---	30
5,750	---	---	30	---
6,000	100	90 & 80	20	20
6,500	30	---	20	---
7,000	30	---	10	---

Parameters

Variables: use of Antenna AS-542/U and EDL folded dipole; range.

Constants	Value	Constants	Value
Antenna polarization	0 deg	Pulse width	2.4 usec
Antenna elevation	Optimum	Delay time	2.4 usec
Attenuation	-9 db	Duty cycle	1/3
Aspect	90 deg	Angle of fire	High, 961.8 mils Low, 408.6 mils
Sweep rate	1.8 sweeps/ sec	Fuzes	NVT

13. TEST 8. FUZE SENSITIVITY

The purpose of the test was to determine the fuze-sensitivity settings most favorable to jamming by the AN/MLQ-8(XL-1).

Early arming of the fuze renders it more susceptible to jamming. A distinct correlation appears between the two curves shown in fig. 11. As the signal strength of the fuze varies, so does its sensitivity appear to vary. The coincidence of the state of low fuze sensitivity with passage of the fuze through the edge of the main lobe of the jammer's transmission, which is a region of high rate of jammer signal, may account for the drop in fuze kill to 30 percent. A slightly later arming time may have placed the state of initial high sensitivity of the fuze in the region of the high rate of change of jammer signal, thus producing the sharp rise in the percentage of fuze kill.

Parameters of the test and results obtained appear in Table VIII.

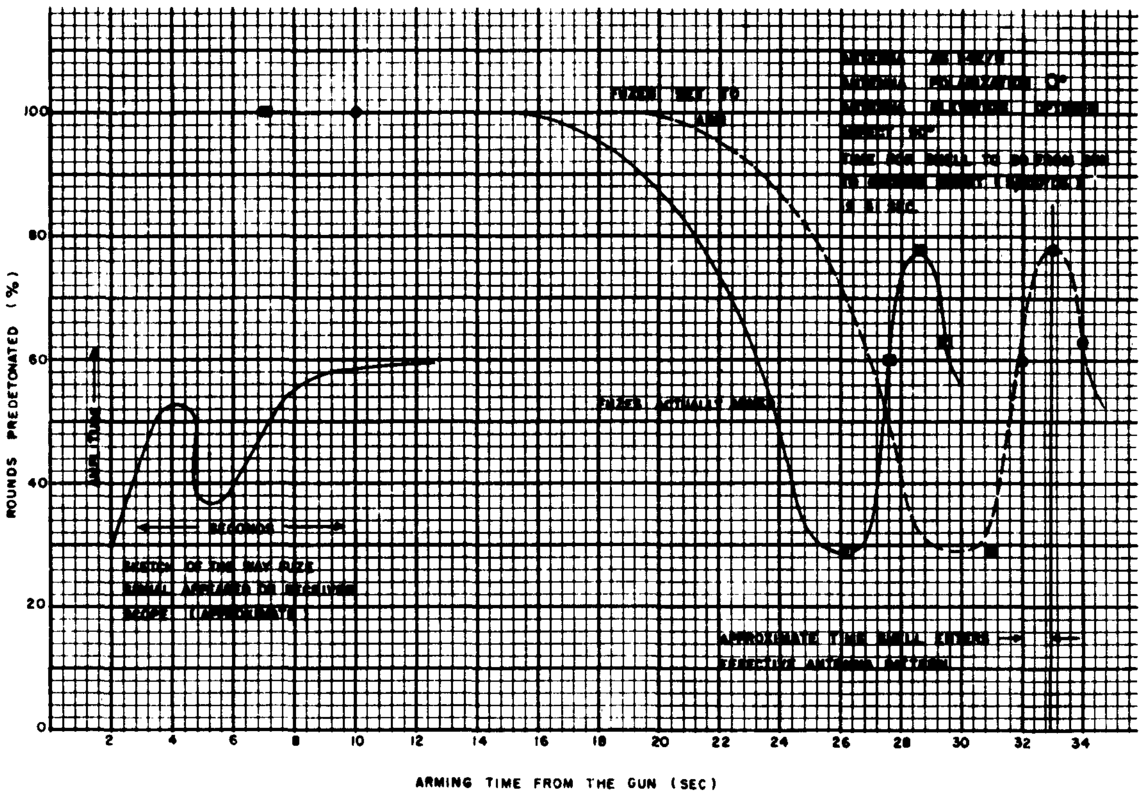

Fig. 11. Percentage of kill as a function of arming time, test 8

Table VIII. Results of Test to Determine Fuze-sensitivity Settings Most Favorable to Jammer

Intended arming time (sec)	Actual arming time[a] (sec)	Rounds predetonated (%)
10	7.0	100
31	26.1	29
32	27.6	60
33	28.8	78
34	29.6	63

Parameters

Variable: arming time of fuzes

Constants	Value	Constants	Value
Antenna polarization	0 deg	Delay time	2.4 usec
Antenna elevation	Optimum	Duty cycle	1/3
Attenuation	Unknown	Angle of fire	High, 1,056 mils
Aspect	90 deg	Range (jammer)	6,750 yards
Sweep rate	1.5 sweeps/ sec	Fuzes	armed as required by this test (T-226E2)
Pulse width	2.4 usec		

[a]"Actual arming time" is an arithmetical average of the intervals after discharge until the fuzes begin transmitting.

Section V. Tests to Determine Effectiveness of the AN/MLQ-8(XL-1)

14. TEST 9. EFFECTIVE RANGE, ASPECT 90 DEGREES, NVT FUZES

The purpose of the test was to determine the range at which the AN/MLQ-8(XL-1) will predetonate 90 percent of NVT fuzes with high and low angles of fire when the jammer is sited at an aspect of 90 degrees to the trajectory. The maximum range for high-angle fire was 15,000 yards; for low-angle fire it was 10,000 yards. The siting arrangements are shown in fig. 23, Annex A.

The results are shown in fig. 12 and in Table IX, which also displays the parameters. In some cases two or more percentages of kill are recorded opposite any one range; this double entry occurs because in some cases guns and jammer positions were changed while the jamming range was kept constant.

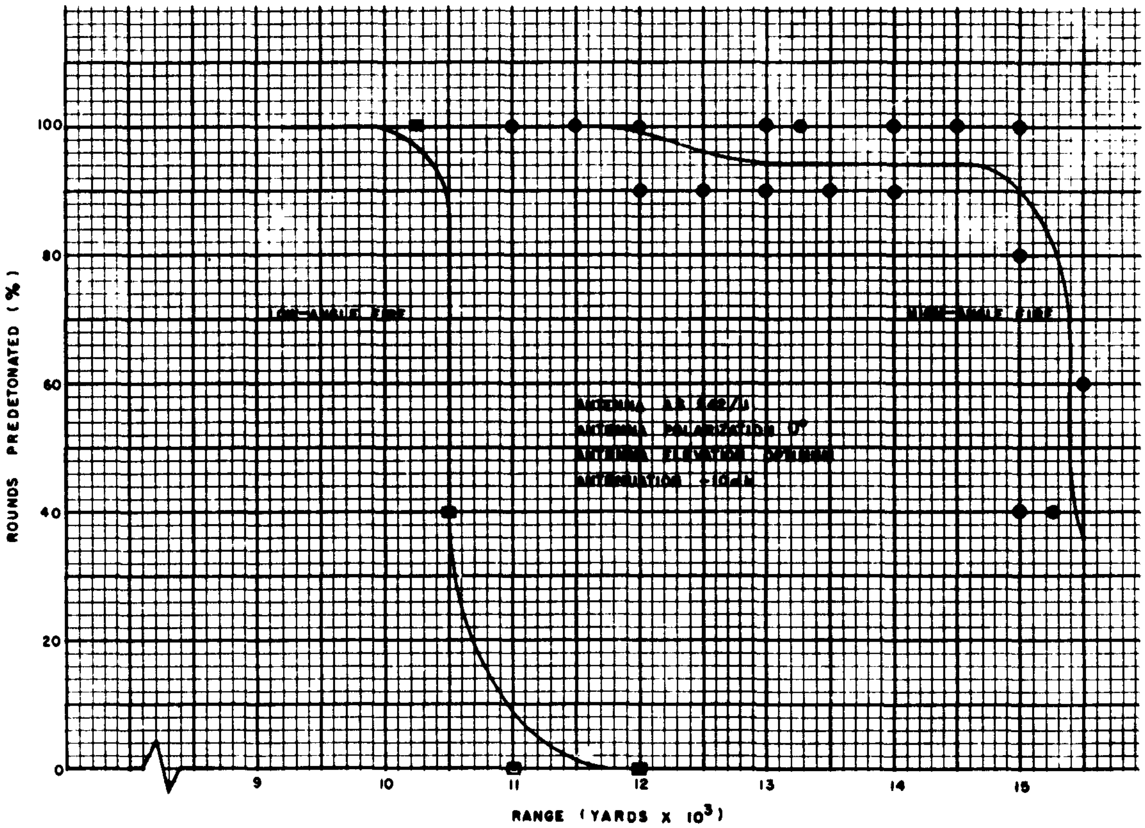

Fig. 12. Percentage of kill as a function of range, 90-degree aspect, high- and low-angle fire, Test 9

Table IX. Results of Test to Determine Effective Range, Aspect 90 Degrees, NVT Fuzes

Range (yds)	Percentage of rounds predetonated	
	High-angle fire	Low-angle fire
10,250	—	100
10,500	—	40
11,000	100	0
11,500	100	—
12,000	100	0
	90	—
12,500	90	—
13,000	90	—
	100	—
13,250	100	—
13,500	90	—
14,000	90	—
	100	—
14,500	100	—
15,000	100	—
	80	—
	40	—
15,250	40	—
15,500	60	—

Parameters

Variable: range

Constants	Value	Constants	Value
Antenna polarization	0 deg	Pulse width	2.4 usec
Antenna elevation	Optimum	Delay time	2.4 usec
Attenuation	-10 db	Duty cycle	1/3
Aspect	90 deg	Angle of fire	High, charge 3 Low, charge 4
Sweep rate	1.5 sweeps/sec (high-angle fire) 2.0 sweeps/sec (low-angle fire)	Fuzes	NVT

15. TEST 10, EFFECTIVE RANGE, ASPECT 45 DEGREES, NVT FUZES

The object of the test was to determine the effective range against NVT fuzes at 45-degree aspect with the equipment sited as shown in fig. 24, Annex A. The results are shown in fig. 13 and are recorded with the parameters in Table X.

The effective range is sharply reduced from that at 90-degree aspect (test 9). The change in aspect angle and the change in antenna polarization combine to drop the effective range to about 40 percent. Note that 10-degree antenna elevation proved to be the best.

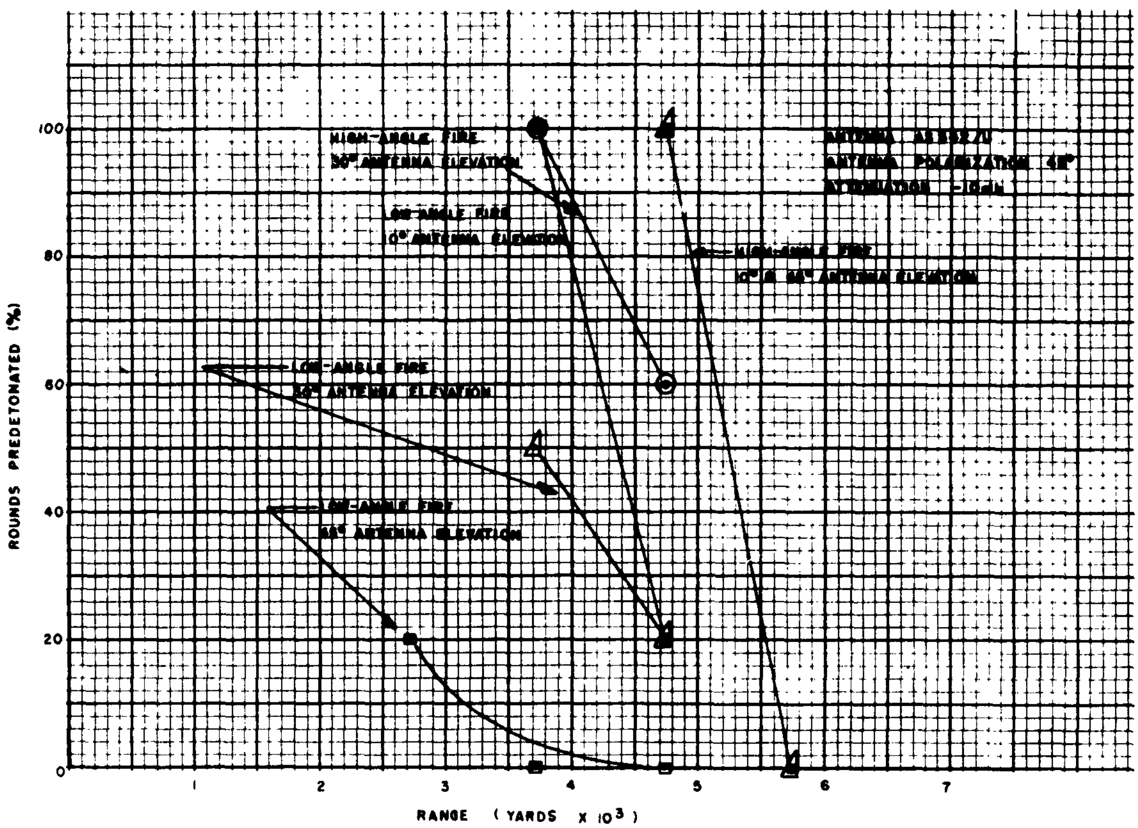

Fig. 13. Percentage of kill as a function of range, aspect 45 degrees, NVT fuzes, high- and low-angle fire, Test 10

Table X. Results of Test to Determine Effective Range, Aspect 45 Degrees, NVT Fuzes

Range (yds)	Percentage of rounds predetonated					
	High-angle fire			Low-angle fire		
	Antenna elevation (deg)			Antenna elevation (deg)		
	10	30	45	10	30	45
2,750	—	—	—	—	—	20
3,750	—	100	—	100	50	0
4,750	100	60	100	20	20	0
5,750	0	—	0	—	—	—

Parameters

Variables: range and antenna elevation

Constants	Value	Constants	Value
Antenna polarization	45 deg	Pulse width	2.4 usec
Attenuation	- 10 db	Delay time	2.4 used
Aspect	45 deg	Duty cycle	1/3
Sweep rate	1.5 sweeps/sec (high-angle fire) 2.0 sweeps/sec (low-angle fire)	Angle of fire	High, charge 3 Low, charge 4
		Fuze	NVT

16. TEST 11, EFFECTIVE RANGE, ASPECT 135 DEGREES, NVT FUZES

The purpose of the test was to determine the effective range for jamming NVT fuzes at an aspect of 135 degrees. The ranges against high- and low-angle fire shown in Table XI, which also gives the parameters, exceeded 7,000 yards. It should be noted that an antenna elevation of 10 degrees was optimal. The siting arrangements are shown in fig. 24, Annex A.

Table XI. Results of Test to Determine Effective Range, Aspect 135 Degrees, NVT Fuzes

Range (yds)	Percentage of rounds predetonated					
	High-angle fire			Low-angle fire		
	Antenna elevation (deg)			Antenna elevation (deg)		
	10	30	45	10	30	45
4,750	100	—	—	—	—	—
6,750	100	100	90	100	100	80

Parameters

Variables: range and antenna elevation

Constants	Value	Constants	Value
Antenna polarization	45 deg	Pulse width	2.4 usec
Attenuation	-10 db	Delay time	2.4 usec
Aspect	135 deg	Duty cycle	1/3
Sweep rate	1.5 sweeps/sec (high-angle fire)	Angle of fire	High, charge 3 Low, charge 4
	2.0 sweeps/sec (low-angle fire)	Fuze	NVT

17. TEST 12, EFFECTIVE RANGE, 0-DEGREE ASPECT, NVT FUZES

The purpose of the test was to determine the effective range against NVT fuzes at 0-degree aspect with siting as shown in fig. 24, Annex A. As shown in Table XII and fig. 14, the jammer provided complete protection from high- and low-angle fire employing NVT fuzes at a jamming range of 1,750 yards with 0-degree aspect.

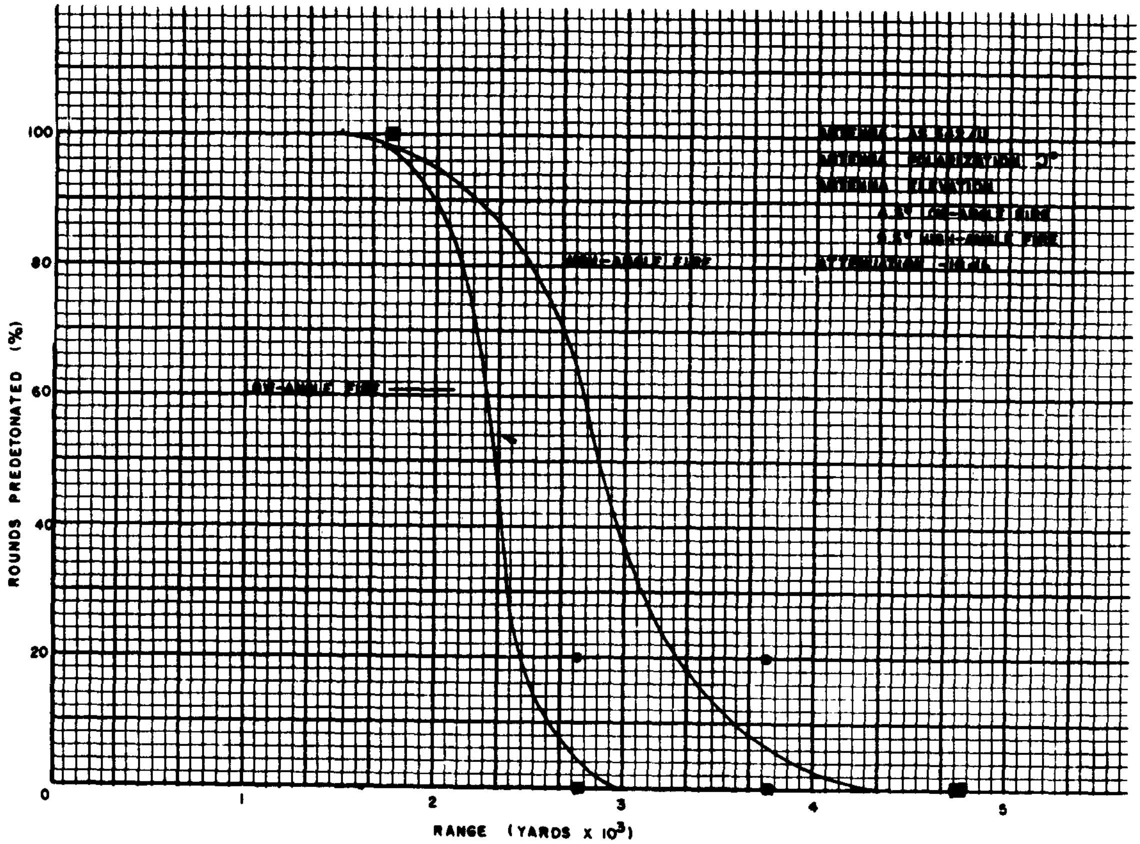

Fig. 14. Percentage of kill as a function of range, aspect 0 degrees, NVT fuzes, high- and low-angle fire, Test 12

Table XII. Results of Test to Determine Effective Range against NVT Fuzes, 0-Degree Aspect

Range (yds)	Percentage of rounds predetonated	
	High-angle fire	Low-angle fire
1,750	100	100
2,750	20	0
3,750	20	0
4,750	0	0

Parameters

Variable: range of jammer

Constants	Value	Constants	Value
Antenna polarization	0 deg	Pulse width	2.4 usec
Antenna elevation	4.5 deg (low angle fire) 9.5 deg (high angle fire)	Delay time	2.4 usec
Attenuation	-10 db	Duty cycle	1/3
Aspect	0 deg	Angle of fire	High (961.8 mils) Low (408.6 mils)
Sweep rate	1.5 sweeps/sec (high-angle fire) 2.0 sweeps/sec (low-angle fire)	Fuzes	NVT

18. TEST 13. EFFECTIVE RANGE, ASPECT 90 DEGREES, CVT FUZES

The purpose of the test was to ascertain the effectiveness of the jammer against CVT fuzes at 90-degree aspect, with siting as shown in fig. 23, Annex A.

Table XIII and fig. 15 show that the optimum elevation of the antenna is still 10 degrees. The 45-degree polarization was selected to optimize coupling between the active CVT fuze and the jammer antenna, just as in test 9 horizontal polarization of the jammer antenna was used to optimize coupling with the NVT fuze. The range against CVT fuzes was cut approximately in half compared to the range against NVT fuzes.

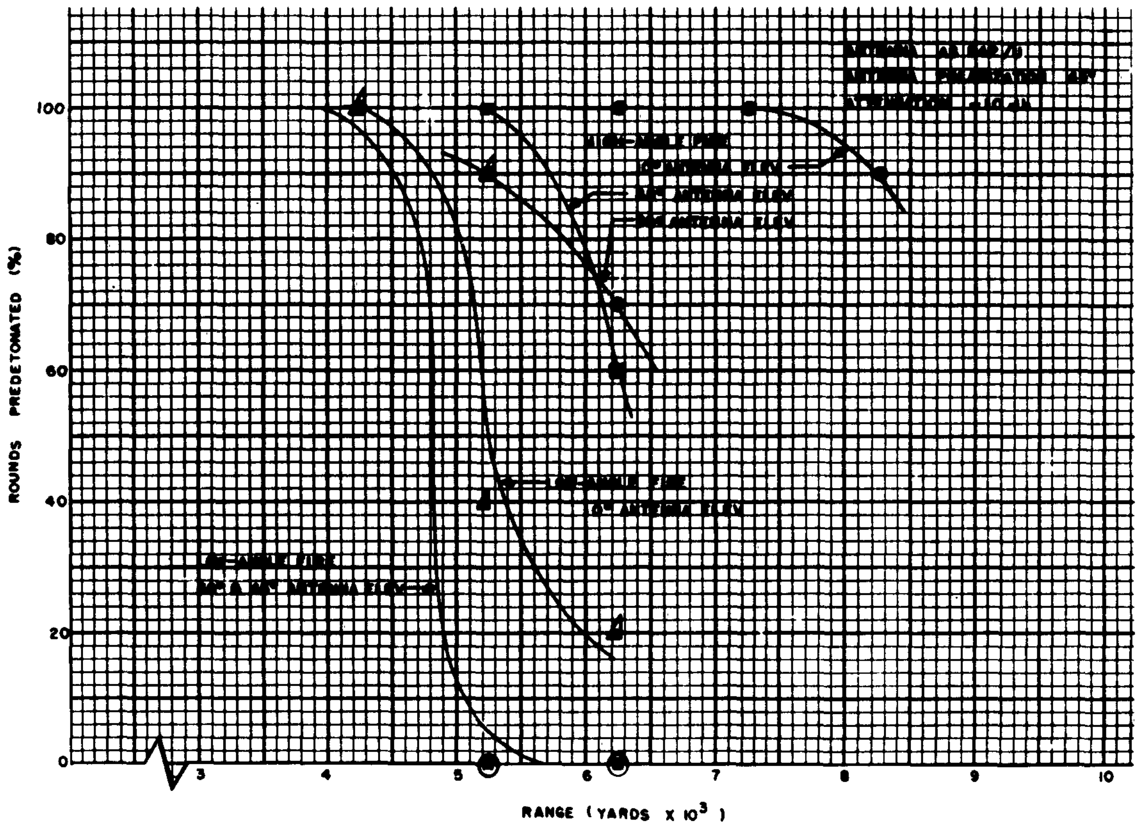

Fig. 15. Percentage of kill as a function of range, aspect 90 degrees, CVT fuzes, high- and low-angle fire, Test 13

Table XIII. Results of Test to Determine Effective Range, Aspect 90 Degrees, CVT Fuzes

Range (yds)	Percentage of rounds predetonated					
	High-angle fire			Low-angle fire		
	Antenna elevation (deg)			Antenna elevation (deg)		
	10	30	45	10	30	45
4,250	—	—	—	100	100	100
5,250	—	90	100	90 and 40	0	0
6,250	100	70	60	20	0	0
7,250	100	—	—	—	—	—
8,250	90	—	—	—	—	—

Parameters

Variables: range and antenna elevation

Constants	Value	Constants	Value
Antenna polarization	45 deg	Pulse width	2.4 usec
Attenuation	-10 db	Delay time	2.4 usec
Aspect	90 deg	Duty cycle	1/3
Sweep rate	1.5 sweeps/sec (high-angle fire)	Angle of fire	High, charge 3 Low, charge 4
	2.0 sweeps/sec (low-angle fire)	Fuzes	CVT

19. TEST 14. EFFECTIVE RANGE, ASPECT 45 DEGREES, CVT FUZES

The purpose of the test was to investigate the effectiveness of the jammer against CVT fuzes when it was sited at an aspect of 45 degrees with varied ranges and antenna elevations. The siting arrangements are shown in fig. 24, Annex A. The results shown in Table XIV and fig. 16 indicate that the effective range at 45-degree aspect dropped some 30 percent from that at 90 degrees with CVT fuzes (test 13). This diminution of effectiveness was to be expected from the 0.707 reduction in coupling between the fuze and the antenna of the jammer.

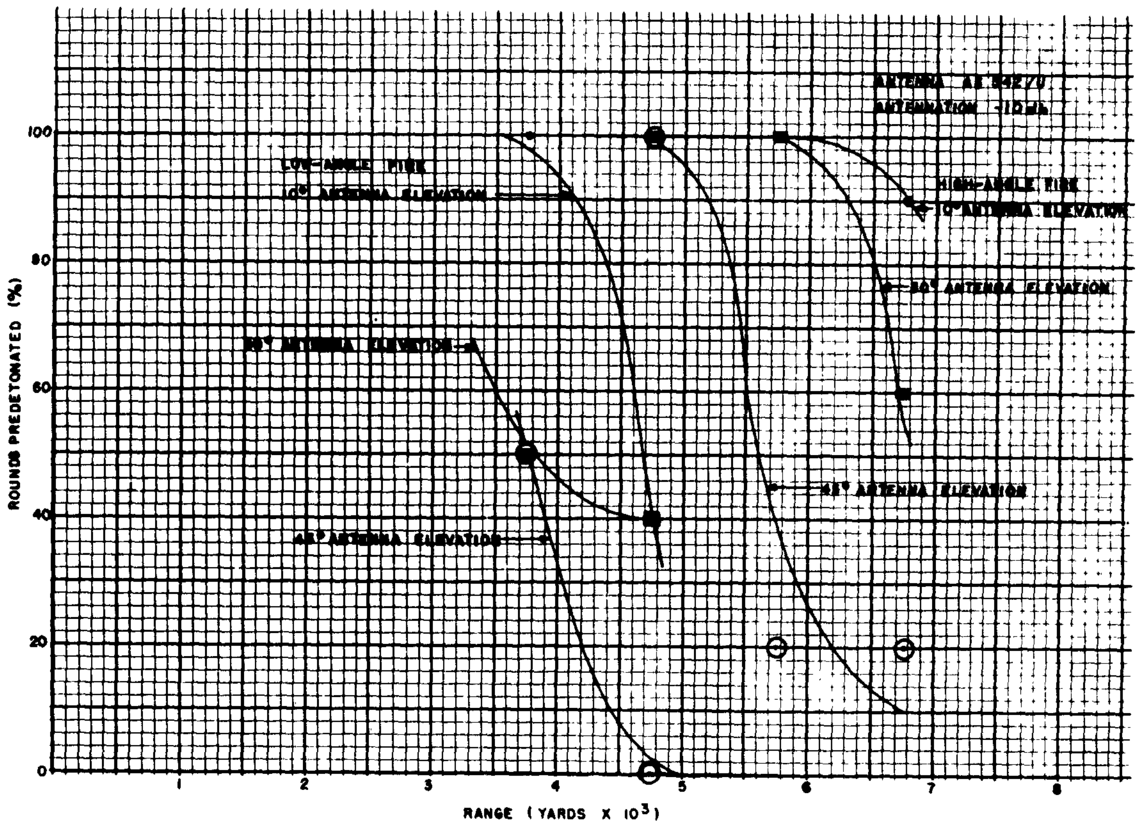

Fig. 16. Percentage of kill as a function of range, aspect 45 degrees, CVT fuzes, for various antenna elevations, high- and low-angle fire, Test 14

Table XIV. Results of Test to Determine Effectiveness, various Ranges and Antenna Elevations

Range (yds)	Percentage of Rounds Predetonated					
	High-angle fire			Low-angle fire		
	Antenna elevation (deg)			Antenna elevation (deg)		
	10	30	45	10	30	45
3,750	—	—	—	100	50	50
4,750	100	100	100	40	40	0
5,750	100	100	20	—	—	—
6,750	90	60	20	—	—	—

Parameters

__Variables__: range and antenna elevation

Constants	Value	Constants	Value
Antenna polarization	45 deg	Pulse width	2.4 usec
Attenuation	-10 db	Delay time	2.4 usec
Aspect	45 deg	Duty cycle	1/3
Sweep rate	1.5 sweeps/sec (high-angle fire)	Angle of fire	High, charge 3 Low, charge 4
	2.0 sweeps/sec (low-angle fire)	Fuze	CVT

20. TEST 15. EFFECTIVE RANGE, ASPECT 135 DEGREES, CVT FUZES

The purpose of the test was to determine the effectiveness of the AN/MLQ-8(XL-1) against CVT fuzes at an aspect of 135 degrees, with the siting shown in fig. 24, Annex A. The results shown in Table XV indicate a distinct drop in range to 25 percent of the range at 90-degree aspect (test 13).

Table XV. Results of Test to Determine Effectiveness, Aspect 135 Degrees, CVT Fuzes

Range (yds)	Percentage of rounds predetonated					
	High-angle fire			Low-angle fire		
	Antenna elevation (deg)			Antenna elevation (deg)		
	10	30	45	10	30	45
2,750	100	90	---	20	40	0
3,750	---	60	100	20 and 60	60 and 0	0
4,750	80	20	100 and 20	25	0	20

Parameters

Variables: range and antenna elevation

Constants	Value	Constants	Value
Antenna polarization	45 deg	Pulse width	2.4 usec
Attenuation	-10 db	Delay time	2.4 usec
Aspect	135 deg	Duty cycle	1/3
Sweep rate	1.5 sweeps/sec (High-angle fire) 2.0 sweeps/sec (Low-angle fire)	Angle of fire	High, charge 3 Low, charge 4
		Fuzes	CVT

21. TEST 16. EFFECTIVE RANGE. ASPECT 0 DEGREES. CVT FUZES

The objective of the test was to determine the range at 0-degree aspect against CVT fuzes, high- and low-angle fire. The siting is shown in fig. 24, Annex A.

The results, shown in Table XVI and fig. 17, indicate an effective range for high-angle fire which seems large compared with the results of other tests. This may have been due to unusual terrain reflections producing unusual effectiveness against high-angle fire. The low-angle fire, however, showed the expected reduction in range for 0-degree aspect to about 20 percent of the effective range for 90-degree aspect. It may be presumed that the high-angle fire would normally suffer a similar reduction; thus the figure of 7,000 yards for 0-degree aspect, high-angle, CVT, should not be accepted since a figure of some 2,000 yards effective range would be more normal.

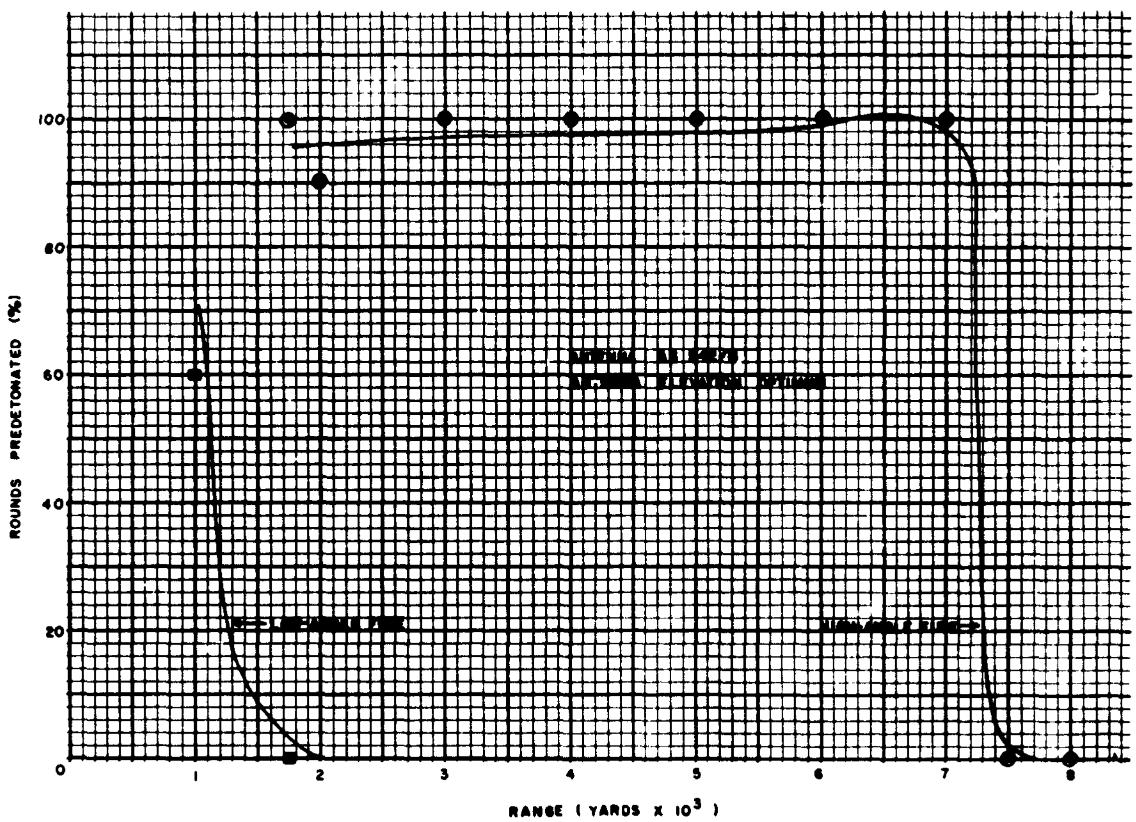

Fig. 17. Percentage of kill as a function of range, 0-degree aspect, CVT fuzes, high- and low-angle fire, test 16

Table XVI. Results of Test to Determine Effective Range, 0-Degree Aspect, CVT Fuzes

Range (yds)	Percentage of rounds predetonated	
	High-angle fire	Low-angle fire
1,000	---	60
1,750	100	0
2,000	90	---
3,000	100	---
4,000	100	---
5,000	100	---
6,000	100	---
7,000	100	---
7,500	0	---
8,000	0	---

Parameters

Variable: range

Constants	Value	Constants	Value
Antenna polarization	0 deg	Pulse width	2.4 usec
Antenna elevation	Optimum	Delay time	2.4 usec
Attenuation	Unknown	Duty cycle	1/3
Aspect	0 deg	Angle of fire	High, charge 3 Low, charge 4
Sweep rate	1.5 sweeps/sec (High-angle fire) 2.0 sweeps/sec (Low-angle fire)	Fuze	CVT

22. TEST 17. AREA PROTECTED EFFECTIVELY

The purpose of the test was to estimate the area effectively protected by the AN/MLQ-8(XL-1) operated singly or in a pair. Siting arrangements appear in fig. 18. The jamming range to the CVT trajectory (gun nr 2) was 6,000 yards, and to a nearby NVT trajectory (gun nr 1) the range was 7,000 yards. Only two guns were used simultaneously; the predetonations nearest to target occurred 1,000 yards from the target of gun nr 2, firing CVT fuzes. Constants of the test are stated in Table XVII.

For 90-degree aspect fire as shown in this test, the area protected is much smaller under CVT fire, perhaps 20 percent of that under NVT fire. Estimating this smaller area from the conditions of this test and from the CVT range tests, a large figure is still obtained since only 90-degree aspect fire was used. Introducing CVT fire at various aspect angles from a 180-degree sector, the area of active predetonations against CVT fire may not exceed 3 square miles, i.e., a trapezoidal area perhaps 5,000 by 2,000 yards. This estimate is made using two jammers 5,000 yards apart with their main antenna axes intersecting symmetrically at 90 degrees and is based on figures concerning the effectiveness of the jammer employed against CVT fire and low-angle fire. The effective ranges concerned were 3,400 yards at 135-degree aspect, 5,100 yards at 90-degree aspect, 4,300 yards at 45-degree aspect, and 1,200 yards at 0-degree aspect.

Table XVII. Constants of Test to Determine Area Protected Effectively

Constants	Value	Constants	Value
Antenna polarization	0 deg	Pulse width	2.4 usec
Antenna elevation	Optimum	Delay time	2.4 usec
Attenuation	-10 db	Duty cycle	1/3
Aspect	90 deg	Range	6,000 and 7,000 yards
Sweep rate	1.5 sweeps/sec	Angle of fire	High, charge 3

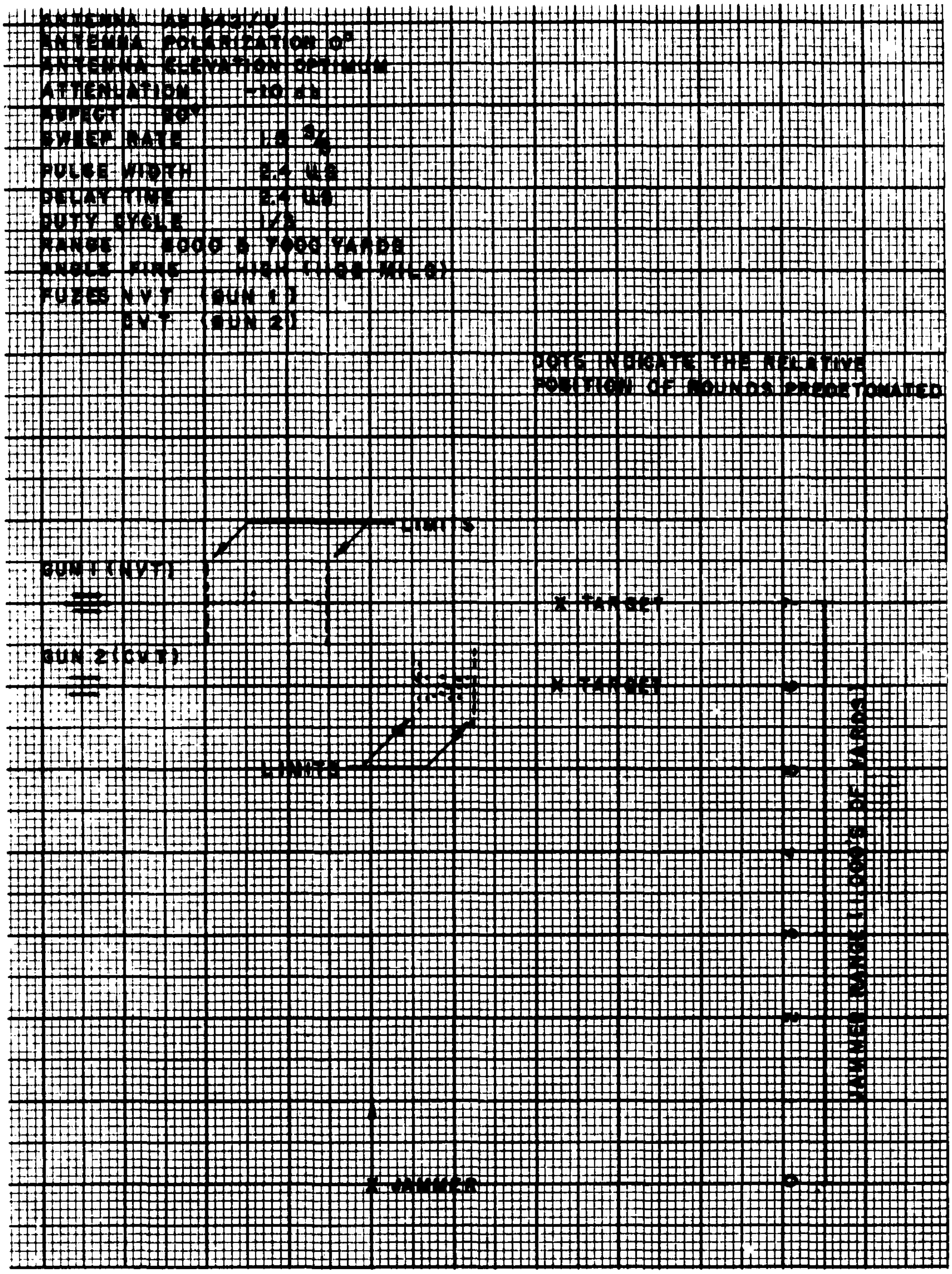

Fig. 18. Relative positions of NVT and CVT predetonations, Test 17

Section VI. Tests to Determine the Vulnerability of the AN/MIQ-8(XL-1) to Unintentional Interference

The purpose of the tests reported in this section was to determine the limitations imposed on the usefulness of the jammer by natural or artificial interference such as might be expected in a tactical situation but not resulting from enemy action.

23. TEST 18. INFLUENCE OF HILLS BEYOND TRAJECTORY

The jammer was sited in such a position that the trajectories of the shells to be predetonated would pass between the jammer and the slopes of a mountain, as illustrated in fig. 25, Annex A. A general comparison of the results with those made to determine the effectiveness of the equipment in relatively unhampered situations (section V) shows that the echo from hills beyond the trajectory reduces the maximum effective range of the jammer as much as 60 percent. The results appear in figs. 19 and 20, and in Table XVIII.

Table XVIII. Results of Test to Determine Influence of Hills beyond Trajectory

Range (yds)	Percentage of rounds predetonated					
	High-angle fire			Low-angle fire		
	Antenna elevation (deg)			Antenna elevation (deg)		
	10	30	45	10	30	45
2,000	100	100	100	100	100	60
3,000	100	100	100	80	60	60
4,000	60	60	100	20	60	60

Parameters

Variables: range of jammer and antenna elevation

Constants	Value	Constants	Value
Antenna polarization	45 deg	Pulse width	2.4 usec
Attenuation	-10 db	Delay time	2.4 usec
Aspect	90 deg	Duty cycle	1/3
Sweep rate	1.5 sweeps/sec (high-angle fire)	Angle of fire	High, charge 3 Low, charge 4
	2.0 sweeps/sec (low-angle fire)	Fuzes	CVT

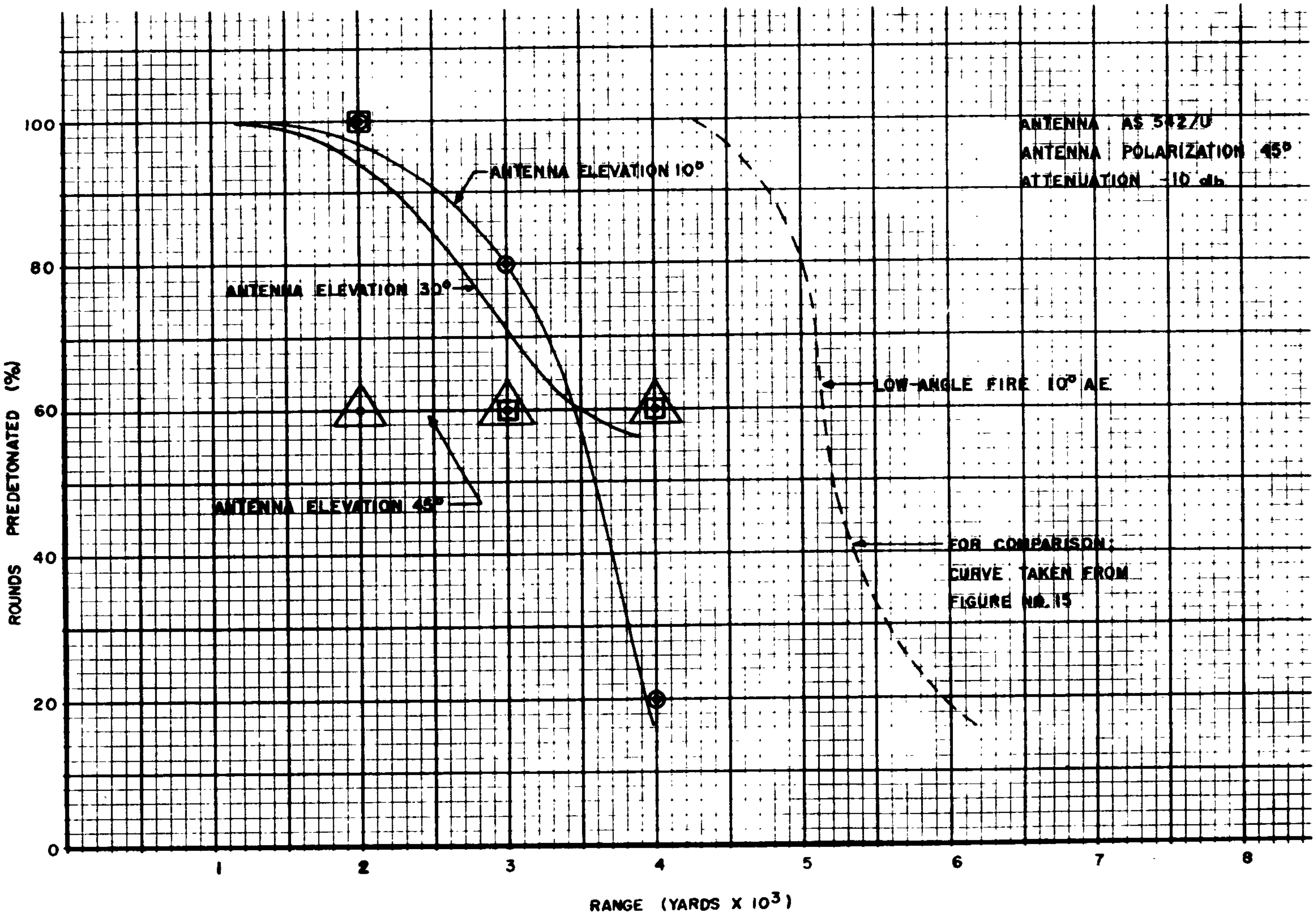

Fig. 19. Percentage of kill as a function of range, 90-degree aspect, with hills beyond trajectory, for various antenna elevations, CVT fuzes, high-angle fire, Test 18

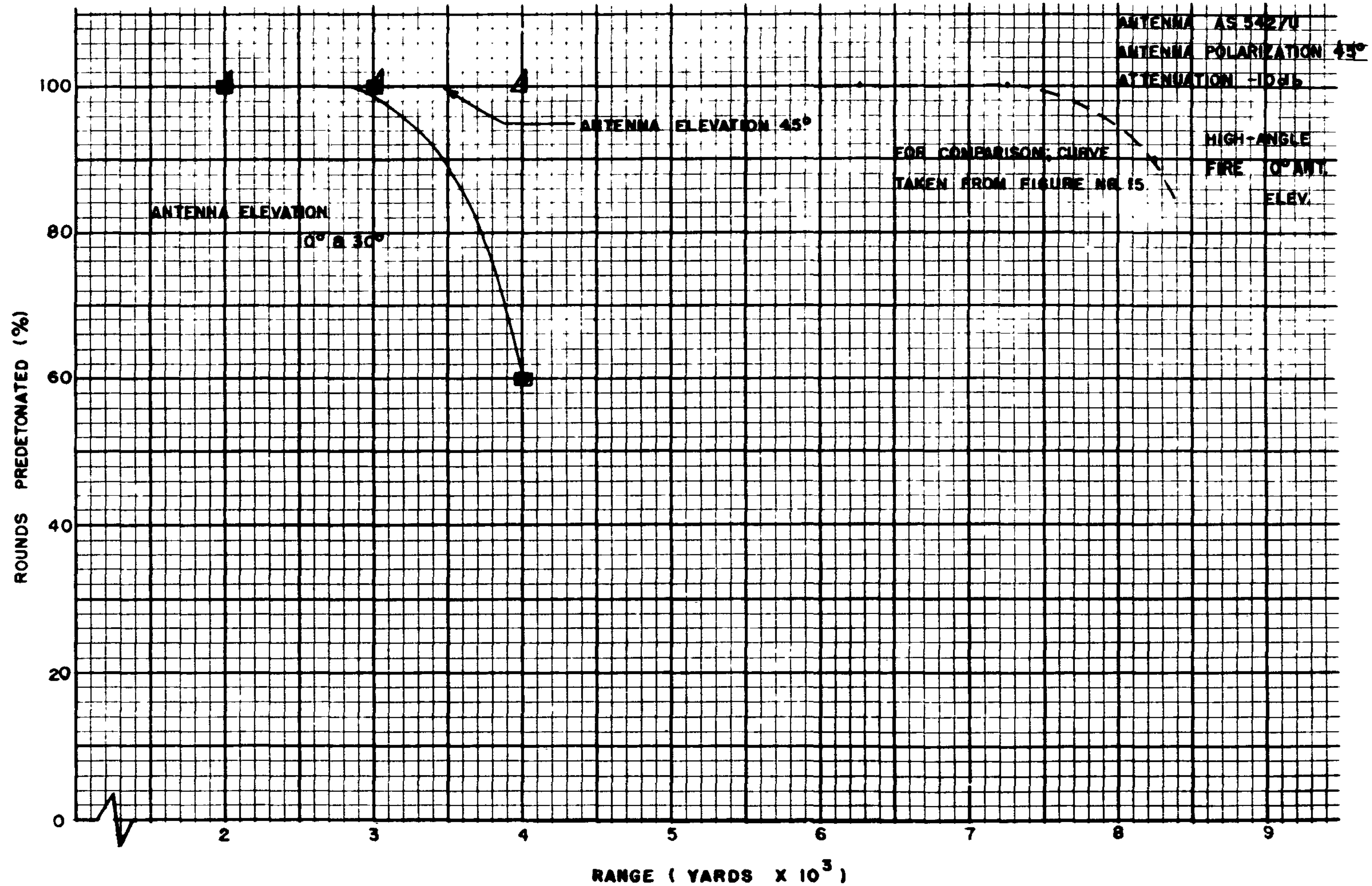

Fig. 20. **Percentage of kill as a function of range,** 90-degree aspect, with hills beyond trajectory, for various antenna elevations, CVT fuzes, low-angle fire, Test 18

24. TEST 19. INFLUENCE OF TREES BETWEEN TRAJECTORY AND JAMMER

The purpose of the test was to ascertain whether foliage intervening between the jammer and the trajectories of shells would diminish the usefulness of the jammer. The siting arrangement appears in fig. 26, Annex A. The range for high-angle fire drops about 50 percent from the range attainable without interfering foliage, and for low-angle fire drops approximately 20 percent, as shown in fig. 21 and Table XIX.

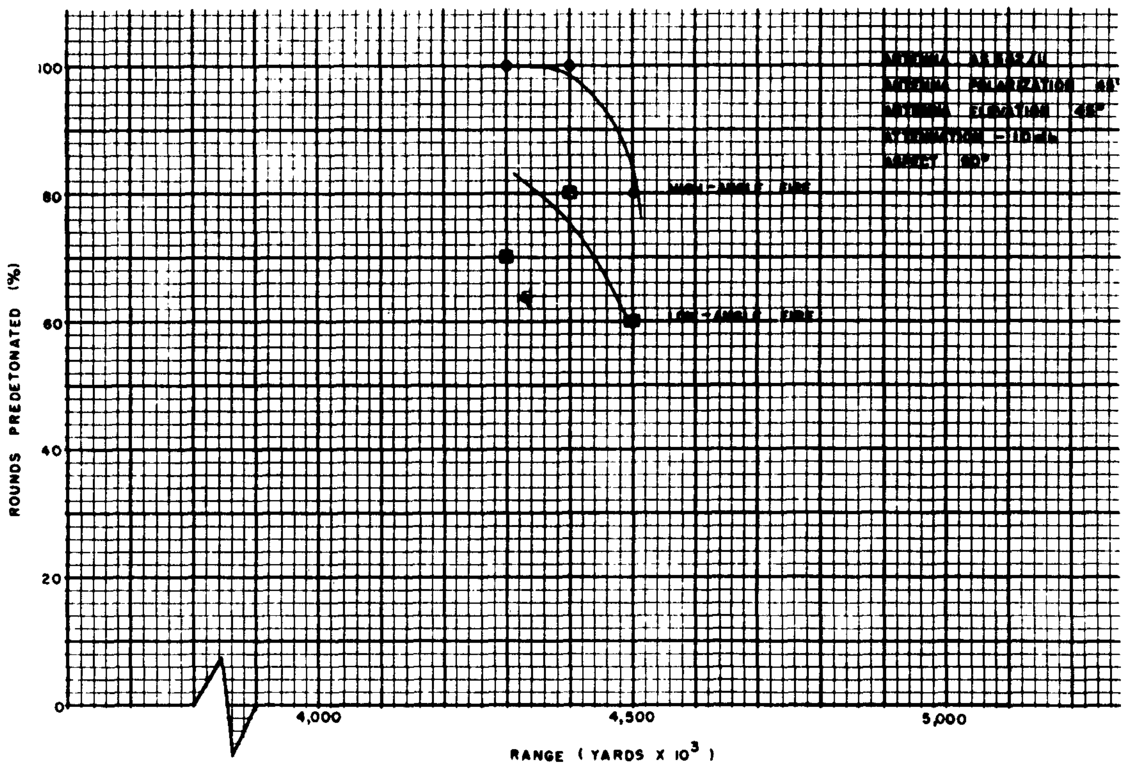

Fig. 21. Percentage of kill as a function of range, 90-degree aspect, with trees between trajectory and jammer, CVT fuzes, high- and low-angle fire, Test 19

Table XIX. Results of Test to Determine Influence of Trees between Trajectory and Jammer

Range (yds)	Percentage of rounds predetonated	
	High-angle fire	Low-angle fire
4,300	100	70
4,400	100	80
4,500	80	60

Parameters

Variable: range

Constants	Value	Constants	Value
Antenna polarization	45 deg	Pulse width	2.4 usec
Antenna elevation	45 deg	Delay time	2.4 usec
Attenuation	-10 db	Duty cycle	1/3
Aspect	90 deg	Angle of fire	High, charge 3 Low, charge 4
Sweep rate	1.5 sweeps/sec (High-angle fire) 2.0 sweeps/sec (Low-angle fire)	Fuze	CVT

25. TEST 20. EFFECT ON FRIENDLY FIRE USING NVT FUZES

The results of the test are best presented in two parts depending upon the vector relationship of the jamming transmission to the emission of the fuzes caused by different polarizations of the antenna of the jammer.

a. Jamming out of Phase with Enemy Fire

In the first part the jammer was sited at successive distances from the trajectory at 90-degree aspect with the axis of its main lobe intersecting the trajectory near the expected point of impact, as shown in fig. 25 (Annex A.) In this part of the test the antenna was polarized at 135 degrees for high-angle fire and at 95 degrees for low-angle fire so that it would be approximately 75 degrees out of phase with the polarization of the fuzes in either case. The results are shown in fig. 22 and Table XX.

b. Jamming with Optimum Polarization to Enemy Fire

In the second part of the test the siting was such that the axis of the main lobe of the jammer intersected the trajectories of two guns at approximately 90-degree aspect to each. The guns were firing at almost opposite azimuths, and their trajectories crossed the main axis of jamming shortly before impact. The jamming range against the friendly gun was approximately half that against the enemy gun which was 4,000 yards. The siting is illustrated in fig. 27 (Annex A.)

The antenna of the jammer was polarized at 45 degrees with respect to the enemy gun so that the axis of the dipole lay in a plane approximately tangent to the trajectory of the enemy fuzes at arming point. Both enemy and friendly guns fired simultaneously.

During high-angle fire the jammer predetonated 100 percent of the enemy rounds, and during low-angle fire it predetonated 80 percent. But the jammer also predetonated 88 of 89 friendly rounds under the circumstances described. It is therefore evident that the AN/MLQ-8(XL-1) may not be expected to operate effectively without interfering with friendly NVT fuzes. CVT fuzes arming outside the field of the jammer will not, of course, be predetonated.

Table XX. Results of Trial to Determine Effect on Jamming with Antenna Polarization 75 Degrees out of Phase

Range (yds)	Percentage of rounds predetonated	
	High-angle fire, polarization 135 deg	Low-angle fire, polarization 95 deg
2,000	—	100
2,500	—	100
3,000	100	40
4,250	—	0
5,250	60	0
7,250	20	0

Parameters

Variables: range and angle of fire

Constants	Value	Constants	Value
Phase distortion of antenna polarization	Approx 75 deg	Pulse width	2.4 usec
Jammer	Ser nr 3	Delay time	2.4 usec
Antenna	AS-542/U	Duty cycle	1/3
Antenna elevation	Optimum	Fuzes	INT
Attenuation	-10 db		
Aspect	90 deg		
Sweep rate, high-angle fire	1.5 s/s		
Sweep rate, low-angle fire	2.0 s/s		

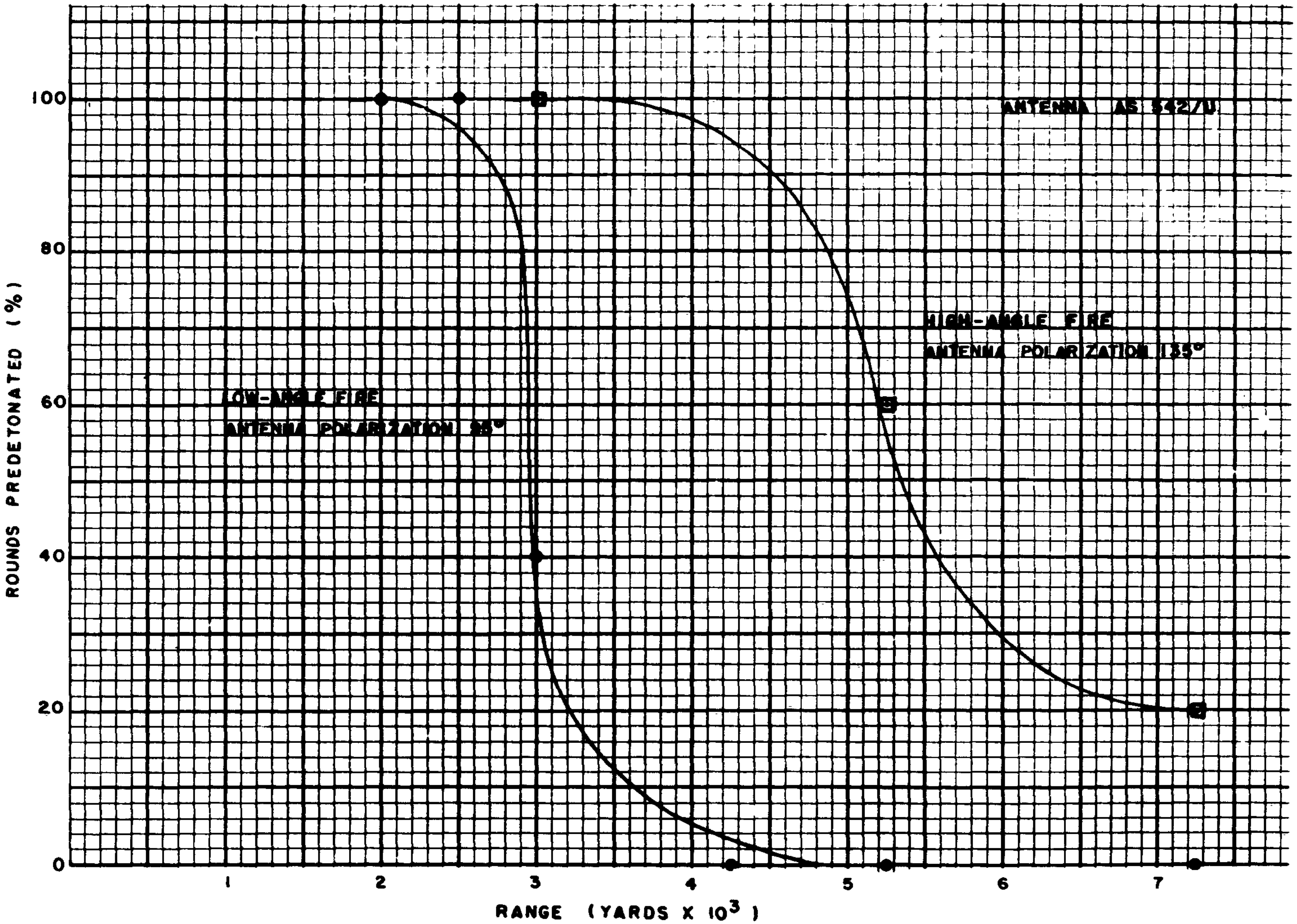

Fig. 22. Percentage of kill of friendly shells as a function of range, 90-degree aspect, CVT fuzes, high- and low-angle fire, Test 20

26. TEST 21. MUTUAL INTERFERENCE BETWEEN TWO JAMMERS

The purpose of the test was to ascertain whether or not two AN/MLQ-8(XL-1) sets would interfere with each other during simultaneous operation and at various sites. Serial numbers 1 and 2 were sited on opposite sides of the trajectory, each at a range of 2,000 yards and opposed to each other in the direction of transmission at 90-degree aspect, as shown in fig. 28 (Annex A.) All rounds were predetonated, and no mutual interference was observed.

Subsequently the sets were sited side by side with their transmissions directed in the same azimuth, but they disclosed no tendency to trigger each other. Further experiments showed that even with sweep rates set the same, the exact synchronization required for "ringing" or loop oscillation is so improbable that the chance of this kind of interference occurring is negligible.

Parameters are recorded in Table XXI.

Table XXI. Parameters of Test of Mutual Interference

Variables: siting and direction of transmission

Constant	Value	Constant	Value
Antenna polarization	horizontal	Pulse width	2.4 usec
Antenna elevation	optimum	Delay time	2.4 usec
Attenuation	-10 db	Duty cycle	1/3
Sweep rate	1.5 sweeps/ sec (high-angle fire)	Range	2,000 yds (for each jammer)
	2.0 sweeps/ sec (low-angle fire)	Angle of fire	High (96[illegible].8 mils) Low (408.6 mils)
		Fuzes	NVT

Section VII. Tests to Determine the Vulnerability of the AN/MLQ-8(XL-1) to Intentional Interference (Counter-countermeasures)

27. TEST 22. COUNTER-COUNTERMEASURES SIGNAL BY AN/TRT-2C

The purpose of the test was to ascertain whether the AN/TRT-2C would interfere with the AN/MLQ-8(XL-1) while the jammer was predetonating CVT fuzes. The AN/TRT-2C was sited at the position of gun 15 as shown in fig. 24, Annex A, so that its axis of transmission coincided with the trajectory of the projectile. The transmitting signal was swept through 138 to 170 Mc/s every half second. The ranges attained by the AN/MLQ-8(XL-1), shown in Table XXII, were not affected by intermittent transmissions of the AN/TRT-2C.

Table XXII. Results of Test of Vulnerability to AN/TRT-2C

Range (yds)	Percentage of rounds predetonated	
	High-angle fire	Low-angle fire
2,250	100	80
3,250	0	0

Parameters

Variables: range and intermittent transmission from AN/TRT-2C

Constant	Value	Constant	Value
Antenna polarization	0 deg	Pulse width	2.4 usec
Antenna elevation	optimum	Delay time	2.4 usec
Attenuation	- 10 db	Duty cycle	1/3
Aspect	0 deg	Angle of fire	High, charge 3 Low, charge 4
Sweep rate	1.5 sweeps/sec (high-angle fire) 2.0 sweeps/sec (low-angle fire)	Fuzes	CVT

28. TEST 23. COUNTER-COUNTERMEASURES SIGNAL BY AN/MRT-4, 90-DEGREE ASPECT

The jammer AN/MRT-4, which was used as counter-countermeasures equipment, was sited in three successive positions as shown in fig. 28 (Annex A) and its signal was beamed at the AN/MLQ-8(XL-1) from each site. The AN/MRT-4 transmitted cw, mcw, bagpipe, audio, and video signals from 1½ to 2 times per second or maintained constant frequency at 165 Mc/s to approximate the conjectural average of the fuze frequency.

The tests showed that with the AN/MRT-4 sweeping, the effect on the AN/MLQ-8(XL-1) was negligible except when a full kilowatt signal was aimed directly into the AN/MLQ-8(XL-1) antenna main axis at a range of 2,000 yards, an event not likely to occur in tactical situations. Stopping the sweep so that the AN/MRT-4 signal centered in the fuze band of frequencies was more effective, especially against high-angle fire, but again this amount of power at such a short range is not likely to occur in actual combat situations. The results of the test are shown in Table XXIII.

Table XXIII. Results of Test to Determine Vulnerability to AN/MRT-4, 90-degree Aspect

Position	AN/MRT-4 Frequency (Mc/s)	Power output (watts)	Percentage of rounds predetonated: Cw	Mcw	Bag-pipe	Audio	Video
High-Angle Fire							
1(592941)	150-170	1,000	100	100	60	100	100
2(617937)	150-170	1,000	100	100	100	100	90
3(603926)	150-170	650	100	100	100	100	90
1(592941)	165	1,000	0	0	0	0	0
2(617937)	165	1,000	No data				
3(603926)	165	750	0	0	20	0	0
Low-Angle Fire							
1(592941)	150-170	1,000	20	20	0	40	40
2(617937)	150-170	1,000	100	100	100	100	100
3(603926)	150-170	650	100	100	100	100	100
1(592941)	165	1,000	0	0	0	0	0
2(617937)	165	1,000	90	100	90	100	100
3(603926)	165	800	80	100	100	100	100

Parameters

Variables: modulation, frequency, and siting of AN/MRT-4

Constant	Value	Constant	Value
Antenna polarization	0 deg	Pulse width	2.4 usec
Antenna elevation	optimum	Delay time	2.4 usec
Attenuation	- 9 db	Duty cycle	1/3
Aspect	90 deg	Range	3,750 yards
Sweep rate	1.5 sweeps/sec (high-angle fire)	Angle of fire	High, charge 3 Low, charge 4
	2.0 sweeps/sec (low-angle fire)	Fuzes	NVT

29. TEST 24. COUNTER-COUNTERMEASURES SIGNAL BY AN/MRT-4, 0-DEGREE ASPECT

The purpose of the test was to determine the effect of the AN/MRT-4 on the AN/MLQ-8(XL-1) when the latter was at 0-degree aspect and the AN/MRT-4 was sited at the position of the gun.

The results shown in Table XXIV dealing with high-angle fire are conclusive and indicate that counter-countermeasures by the AN/MRT-4 reduce the jamming range of the AN/MLQ-8(XL-1) by approximately 1,000 yards. (For low-angle fire there is a corresponding reduction in range.)

Table XXIV. Results of Test of Vulnerability to AN/MRT-4, 90-Degree Aspect

Range (yds)	Percentage of rounds predetonated			
	High-angle fire		Low-angle fire	
	Antenna elevation		Antenna elevation	
	Optimum	Horizontal	Optimum	Horizontal
1,000	--	--	20	80
2,000	100	--	--	--
4,000	100	--	--	--
6,000	90	--	--	--
7,000	20	--	--	--

Parameters

Variable: range of jammer

Constant	Value	Constant	Value
Antenna polarization	Unknown	Pulse width	2.4 usec
Antenna elevation	Optimum, horizontal	Delay time	2.4 usec
Attenuation	Unknown	Duty cycle	1/3
Aspect	0 deg	Angle of fire	High, charge 3 Low, charge 4
Sweep rate	1.5 sweeps/sec (high-angle fire) 2.0 sweeps/sec (low-angle fire)	Fuzes	CVT
		AN/MRT-4	at gun position

Section VIII. Discussion of Test Results

30. OPERATING PARAMETERS

The optimum operating parameters of the AN/MLQ-8(XL-1) are presented in Sec IX, 1. The optimum antenna elevation was 10 degrees.

Use of the maximum power output produced the most satisfactory results (Test 6). The AN/MLQ-8(XL-1) is equipped with a series of attenuation switches, various combinations of which reduce the power output. The maximum power output is obtained by bypassing the attenuator completely. Throughout this report, maximum power is indicated whenever -10 db attenuation is stated (maximum gain).

31. FUZE SENSITIVITY

Variations in the arming times of the fuzes were definitely correlated with the observed signal amplitude behavior of the fuzes for the first few seconds after coming on the air.

32. EFFECTIVENESS

The maximum effective ranges of the AN/MLQ-8(XL-1) are set forth in Table XXV of Sec IX. Maximum ranges for NVT fire were 15,000 yards for high-angle and 10,500 yards for low-angle. Maximum ranges for CVT fire were 8,250 yards for high-angle and 5,250 yards for low-angle.

The results of the friendly-fire test (Test 20) show that the AN/MLQ-8(XL-1) will detonate friendly NVT fuzes as well as enemy shells. The CVT technique, in which the fuze is not armed until within 3 seconds of its objective, would minimize this problem.

The effectiveness of the AN/MLQ-8(XL-1) was not reduced by mutual interference of two jammers (Test 21).

It was considered necessary by operators of the AN/MLQ-8(XL-1) that a monitor receiver having the same frequency band be used in conjunction with this jammer.

33. AREA PROTECTED

The area protected effectively (Test 17) by the AN/MLQ-8(XL-1) is governed by many factors, such as use of CVT or NVT fuzes, aspect angle, terrain conditions, number of simultaneous rounds, and presence

of interfering signals. If two jammers are arranged 5,000 yards apart with antenna beams intersecting at 90 degrees, the area within which all CVT and NVT fuzes will be predetonated may be considered to be roughly rectangular in shape of some 5,000 by 2,000 yards with the longer dimension extending along the baseline between the two jammers. If the enemy fire is from any direction within a 180-degree sector forward of the baseline between the two jammers, an additional "shadow" area behind the baseline is protected, because shells aimed at the shadow area would have to pass through the forward coverage of the jammers and would be predetonated there. The total area protected in this case would be about 6 square miles.

34. VULNERABILITY

The AN/MLQ-8(XL-1) was not vulnerable to a counter-countermeasures signal from the AN/TRT-2C (Test 22). It was vulnerable to counter-countermeasures signals from the AN/MRT-4 only under conditions which would be highly improbable in a tactical situation. There was a small reduction in range (1,000 yards) when the AN/MRT-4 was set to a fixed frequency and used at a range of 6,000 yards.

35. FURTHER TESTING

An additional interference test was conducted by aiming the AN/MLQ-8(XL-1) at the Libby Airfield control tower from a distance of 1 mile. Tower operators reported their vhf circuits (Aircraft Radio Corp., Type 12) were bothered by an annoying rattle or buzz, but that no communications were interrupted. Light aircraft pilots also reported similar effects. It is indicated that the AN/MLQ-8(XL-1) can be used in fairly close proximity to vhf communication links without disrupting communications.

Section IX. Conclusions

1. The optimum operating parameters of the AN/MLQ-8(XL-1) are as follows:

Parameter	Optimum Value
Sweep rate	1.5 sweeps/sec (High-angle fire) 2.0 sweeps/sec (Low-angle fire)
Duty cycle	1/3
Pulse width	2.4 usec
Delay time	2.4 usec
Antenna polarization	0 deg, NVT 45 deg, high-angle CVT
Antenna elevation	10 deg
Power output	maximum
Antenna type	AS-542/U

2. The effectiveness of the AN/MLQ-8(XL-1) in terms of maximum effective ranges obtainable under various conditions is set forth in Table XXV. In general, the AN/MLQ-8(XL-1) is most effective when used with optimum parameters (1. above) against NVT fuzes and deployed at 90-degree aspect with antenna elevated at optimum elevation (approximately 10 degrees).

   The maximum effective range of the AN/MLQ-8(XL-1) when the antenna axis is facing a hill (Test 18) is reduced by 4,750 yards for high-angle fire and by 2,000 yards for low-angle fire.

   The maximum effective range of the AN/MLQ-8(XL-1) when the antenna axis is facing trees which are between the jammer and the trajectory (Test 19) is approximately 4,500 yards for high-angle fire. This is a reduction in maximum effective range of about 1,250 yards.

Table XXV. Maximum Effective Ranges of the AN/MLQ-8(XL-1)[a]

Fuze (type)	Angle of fire	Aspect (deg)	Antenna polarization (deg)	Ant. elev (deg)	Max. eff. Range[b] (yds)	Reference Test (nr)
NVT	High	90	0	Opt[d]	15,000	9
	Low			Opt[d]	10,500	
NVT	High	45	45	10	5,000	10
	High			30	4,000	
	High			45	5,000	
	Low			10	3,750	
	Low			30	c	
	Low			45	c	
NVT	High	135	45	10	c	11
	High			30	c	
	High			45	c	
	Low			10	c	
	Low			30	c	
	Low			45	c	
NVT	High	0	0	Opt[d]	2,250	12
	Low			Opt[d]	2,000	
CVT	High	90	45	10	8,250	13
	High			30	5,250	
	High			45	5,750	
	Low			10	5,250	
	Low			30	4,500	
	Low			45	4,500	
CVT	High	45	45	10	6,750	14
	High			30	6,250	
	High			45	5,250	
	Low			10	c	
	Low			30	c	
	Low			45	c	
CVT	High	135	45	10	3,750	15
	High			30	2,750	
	High			45	c	
	Low			10	c	
	Low			30	c	
	Low			45	c	
CVT	High	0	0	Opt[d]	7,250	16
	Low			Opt[d]	1,250	

[a]Common constants are optimum operating parameters from the table of 1., preceding, with the exception of antenna polarization.
[b]See definition of maximum effective range in Annex B.
[c]Maximum effective range not determined.
[d]See definition of optimum antenna elevation in Annex B.

3. The vulnerability of the AN/MLQ-8(XL-1) is greater when the frequency of a counter-countermeasures (CCM) signal is approximately equal to the frequency of the fuze signal, rather than when the CCM signal is swept through a band of frequencies. The set is most vulnerable to a CCM signal when the axes of the CCM equipment and the jammer coincide and are directly opposed in azimuth. The jammer is slightly more vulnerable to a bagpipe signal than to other types of signal used in the test (see Table XXIII). At tactical ranges the reduction in range of the jammer is negligible.

4. Incorporation of visual means of viewing signals from all moving targets within the AN/MLQ-8(XL-1) frequency band is desirable.

5. Further procurement of the AN/MLQ-8(XL-1) in its present form is not indicated. This set is an experimental model and therefore no testing of ruggedness, portability, maintenance, and similar factors was appropriate.

6. A smaller tactical version of the AS-542/U antenna is needed. The EDL folded dipole and Telrex X-100 antennas, although acceptable in size, were much more sensitive to terrain reflections than the AS-542/U.

ANNEX A. SITING ARRANGEMENTS

Figs. 23 to 28 which follow are drawn so that the gun and jammer coordinates can be determined. The coordinates of the targets are approximate. The sites and trajectories cover a portion of maps AMS SERIES V898, Sheets 3947 111 SW and 3947 111 SE.

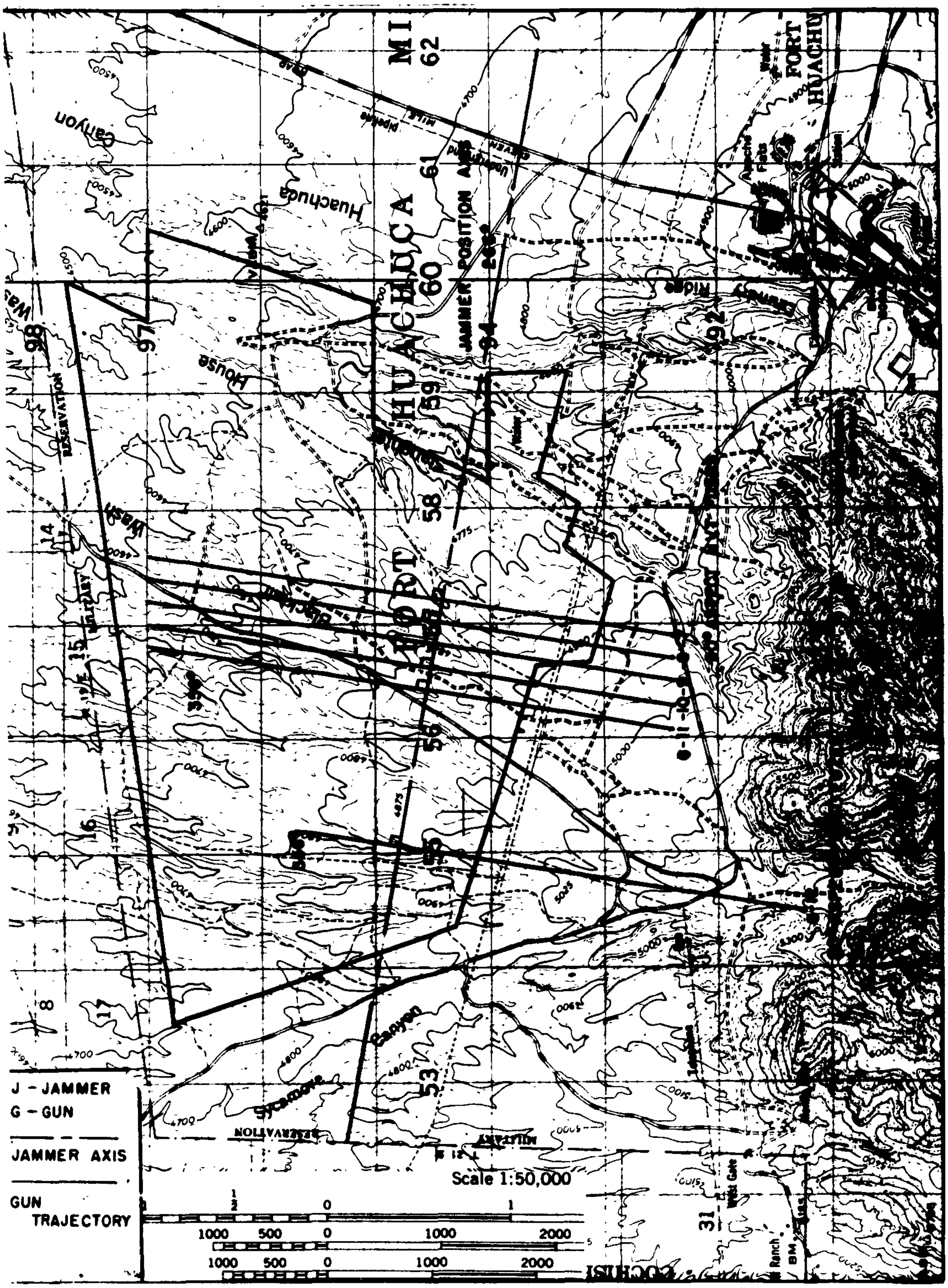

Fig. 23. Siting arrangement for Tests 1 through 7, 9, and 13, 90-degree aspect

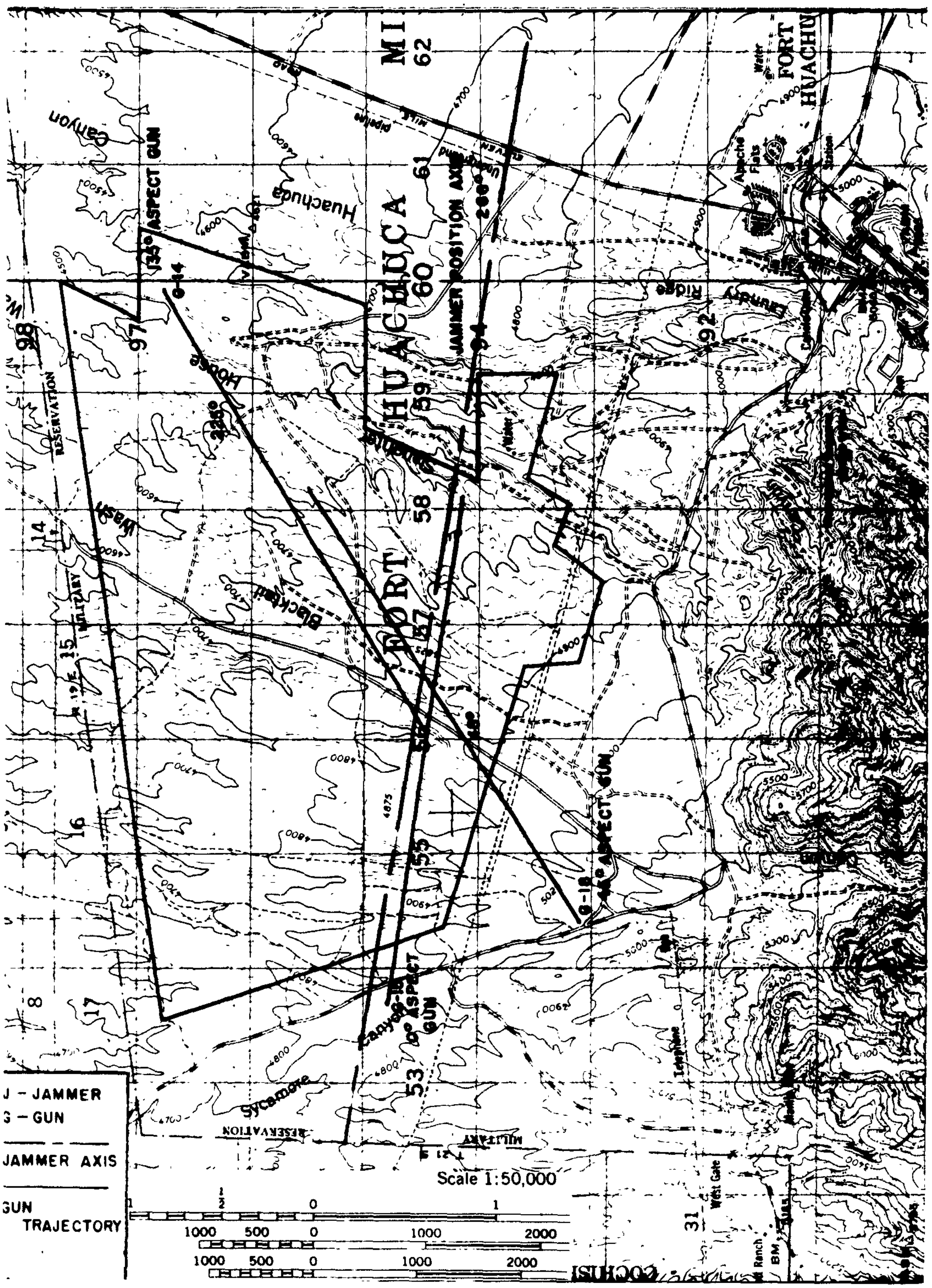

Fig. 24. Siting arrangement for Tests 10, 11, 12, 14, 15, 16, and 22, aspects of 0, 45, and 135 degrees

SECRET

Fig. 25. Siting arrangement for Test 18

SECRET

Fig. 26. Siting arrangement for Test 19

Fig. 27. Siting arrangement for Test 20

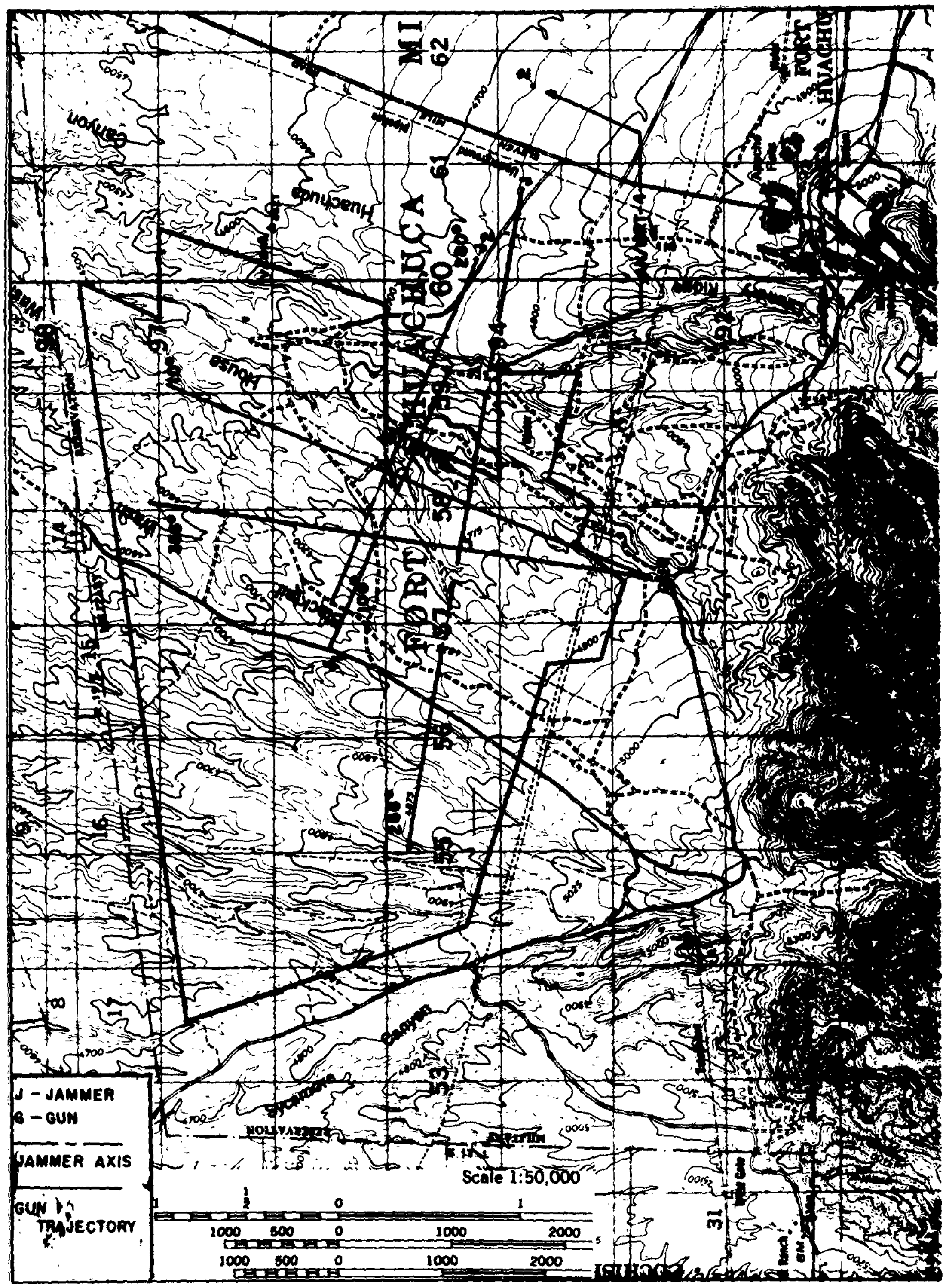

Fig. 28. Siting arrangement for Tests 21 and 23

ANNEX B. DEFINITIONS

Antenna Polarization:

The angle in degrees to which the antenna dipole is set, measured from the horizontal position toward the angle of fall of the projectile, seen in the direction of jamming

Aspect:

The angle between the projections on the horizontal plane of the projectile's trajectory and the axis of the main lobe of the jammer antenna, measured in degrees from the direction of flight of the projectile to the projection of the jammer axis (See fig. 29)

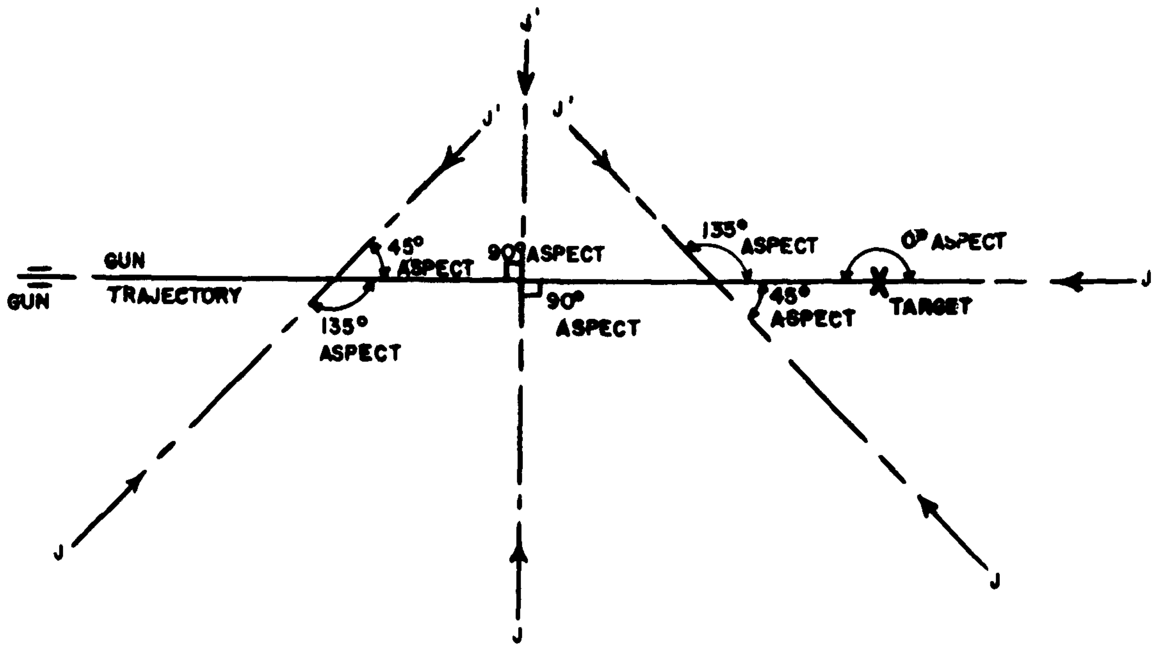

Fig. 29. Diagram of Aspect

CVT Fuzes:

Fuzes that are set so their electronic radiations start 3 seconds before expected impact time (Controlled Variable Time Fuzes)

Delay Time:

The time, expressed in microseconds, during which the received signal is held in the coaxial delay lines of the AN/MLQ-8(XL-1)

Duty Cycle:

The ratio of pulse width to one complete cycle, or a : b in fig. 30

Maximum Effective Range:

The range beyond which less than 90 percent of the rounds are pre-detonated

NVT Fuzes:

Fuzes that begin to transmit signals 7 to 10 seconds after leaving the gun (Normal Variable Time Fuzes)

Optimum Antenna Elevation:

When NVT fuzes are used, the angle of elevation of the antenna axis necessary to aim it at the point where the artillery projectile reaches maximum altitude

When CVT fuzes are used, the angle of elevation of the antenna axis necessary to aim it at the point where the fuze is expected to arm

Pulse Width:

The time, expressed in microseconds, during which the AN/MLQ-8(XL-1) is transmitting (see fig. 30)

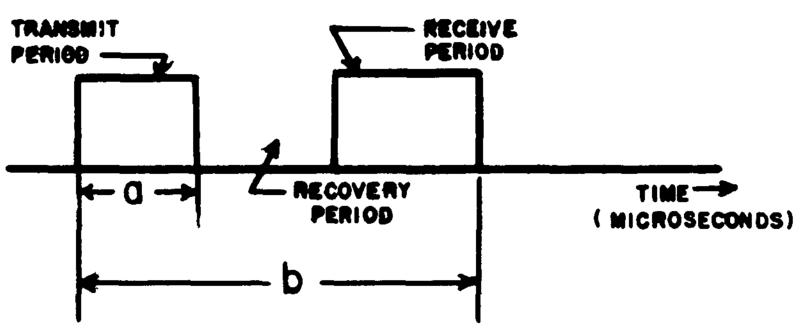

Fig. 30. One cycle of AN/MLQ-8(XL-1) transmission

ANNEX C. COMPARATIVE STUDY OF AN/MLQ-8(XL-1) and (XL-2)

During tests of the AN/MLQ-8(XL-2), which is an improved tactical version of the AN/MLQ-8(XL-1), a test to compare the XL-1 and the XL-2 was conducted to determine which of the two sets was more effective in countering T-226E2/A VT fuzes. The test was conducted at 90-deg aspect with fuzes set for NVT action and using optimum parameters. The results clearly indicated that the XL-1 was superior to the XL-2 in maximum effective range attained. To eliminate a possible variation in space patterns of the antenna, the same antenna was used, in the same position, for both equipments.

To determine whether the shorter time-on-signal of the XL-2, 20 milliseconds, compared to that of the XL-1, 90 milliseconds, might be the major cause of the difference in performance, the XL-1 was field modified to reduce its time-on-signal to 60 milliseconds. The maximum effective range of the XL-1 was then checked under field conditions identical to those which preceded the modification. Results showed that the reduction in time-on-signal had caused a deterioration in effectiveness. The results of this test are shown in Table XXVI and in fig. 31.

A comparison of the XL-1 and the XL-2 in respect to the number of sweeps required to predetonate a fuze shows that the XL-1 often prefunctions the fuzes on the first sweep, while the XL-2 requires on the average 5 sweeps, and on occasion as much as 17 sweeps to prefunction a fuze. This distinct superiority of the XL-1 over the XL-2 has not to date been definitely proved to be due to the greater time-on-signal, but the field checks made to date are strongly indicative that the difference in time-on-signal is a major factor contributing to the difference in the number of sweeps required by each equipment. The number of sweeps required by the (XL-2) to prefunction a fuze is shown in Table XXVII.

Limited experimentation with the duty cycle of the XL-2 showed no significant difference in performance resulting from alternations between duty cycles of 1/3 and 1/3.5. The results of the duty cycle test appear in fig. 32.

Although at this time it is not conclusively proved that more time-on-signal will greatly increase the range of the XL-2, the field checks made indicate that significantly greater range effectiveness may be expected if the time is extended to at least 30 milliseconds. Beyond this point, range may increase only slightly. However, the greater time-on-signal of the XL-1, 90 milliseconds, compared to the lesser, 20 milliseconds, time-on-signal of the XL-2 may account for

Table XXVI. Relation of Time-on-signal to Kill

<table>
<tr><th rowspan="3">Time-on-signal (ms)</th><th rowspan="3">Antenna elevation (deg)</th><th rowspan="3">Duty cycle</th><th rowspan="3">Range (yds)</th><th colspan="3">Percentage of kill</th></tr>
<tr><th colspan="2">XL-1</th><th rowspan="2">XL-2</th></tr>
<tr><th>(unmod)</th><th>(mod)</th></tr>
<tr><td>20</td><td>0</td><td>1/3.5</td><td>7,500</td><td rowspan="6">N/A</td><td rowspan="10">N/A</td><td>60</td></tr>
<tr><td>20</td><td>13</td><td>1/3.5</td><td>7,500</td><td>80</td></tr>
<tr><td>20</td><td>0</td><td>1/5</td><td>7,500</td><td>100</td></tr>
<tr><td>20</td><td>0</td><td>1/3.5</td><td>9,000</td><td>20</td></tr>
<tr><td>20</td><td>13</td><td>1/3.5</td><td>9,000</td><td>20</td></tr>
<tr><td>20</td><td>0</td><td>1/5</td><td>9,000</td><td>60</td></tr>
<tr><td>90</td><td>0</td><td>1/3</td><td>9,000</td><td>80</td><td rowspan="7">N/A</td></tr>
<tr><td>90</td><td>13</td><td>1/3</td><td>9,000</td><td>80</td></tr>
<tr><td>90</td><td>0</td><td>1/3</td><td>10,500</td><td>80</td></tr>
<tr><td>90</td><td>8</td><td>1/3</td><td>10,500</td><td>60</td></tr>
<tr><td>60</td><td>13</td><td>1/3</td><td>9,000</td><td rowspan="3">N/A</td><td>80</td></tr>
<tr><td>60</td><td>0</td><td>1/3</td><td>10,500</td><td>40</td></tr>
<tr><td>60</td><td>8</td><td>1/3</td><td>10,500</td><td>40</td></tr>
<tr><td colspan="7">Constants of the Test

Basis, 5 significant shells; high-angle fire; horizontal polarization; NVT fuzes armed 9 sec after firing; 105-mm howitzer; 90-deg aspect; XL-1, 1.5 sweeps/sec; XL-2, 1.6 sweeps/sec.</td></tr>
</table>

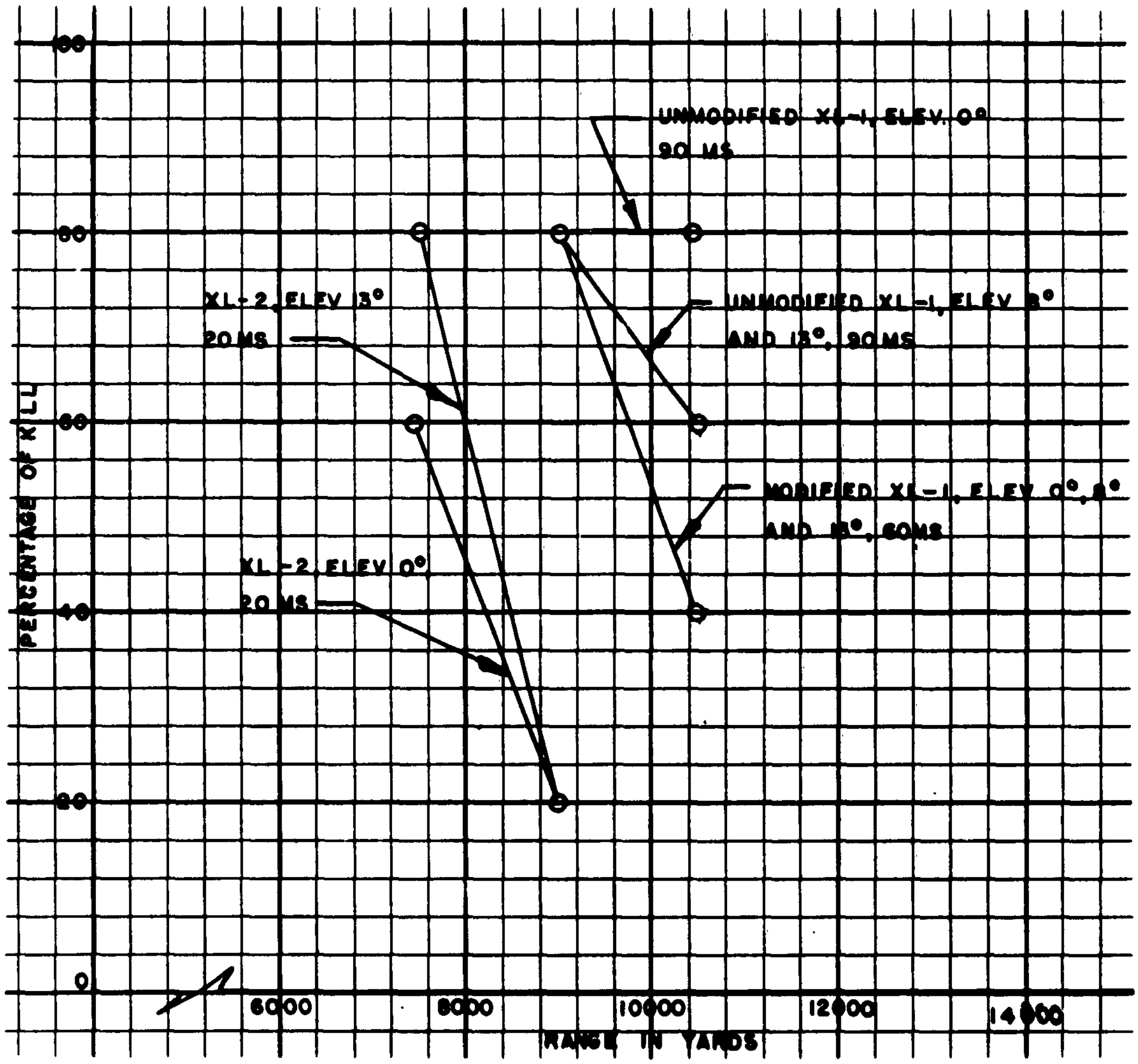

Fig. 31. Decrease in range with decrease in time-on-signal

Table XXVII. Number of sweeps required by the AN/MLQ-8(XL-2)

Ranges (yds)	Sweeps (average nr)	Shells (nr)
2,700	4.4	5
4,200	5.5	4
	4.5	4
4,800	6.0	1
	6.3	3
	6.0	2
	7.1	8
	4.3	3
	4.5	2
	4.5	6
5,000	9.7	4
	5.0	5
	7.0	5
	5.0	4
5,900	4.3	3
	4.8	10
	4.9	10
	4.7	8
	5.7	6
	5.1	8
	6.1	8
	5.7	4
	5.3	3
	7.5	2
	6.7	3
	4.7	8
	4.0	3
	Average 5.45	132

Constants of the test

NVT fuzes armed 6 sec after firing; horizontal polarization; 90-deg aspect; jeep-mounted antenna.

the inability of the XL-2 to predetonate a fuse on the first or second sweep.

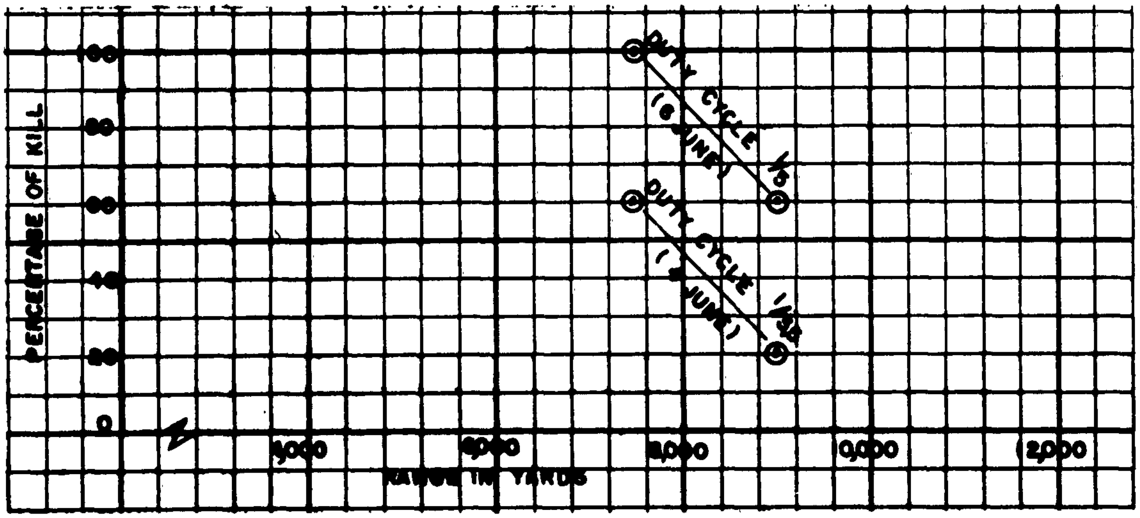

Fig. 32. Effect of duty cycle on kill of the AN/MLQ-8(XL-2)

Considering the results of this comparison, it is evident that the XL-1 is more effective than the XL-2 and that the increased effectiveness may be due to the longer time-on-signal of the XL-1.

Figs. 1 (p. 13) and 33 are block diagrams of the XL-1 and the XL-2. An examination of the two diagrams reveals that although the basic units of the system as a whole were not changed in fabricating the XL-2, certain differences do exist. These are principally the frequency of operation and the locations of the various units.

One electrical difference that resulted from the modification of the original XL-1 system, however, is the change in system bandwidth. In the XL-2 the system bandwidth is from 3 to 5 Mc/s, while in the XL-1 the system bandwidth is from 9 to 12 Mc/s.

No attempt was made to perform a detailed analytic circuit comparison between the two sets, but the failure of the XL-2 to match or better the performance of the XL-1 may be the result of a combination of these changes as well as the lack of sufficient time-on-signal.

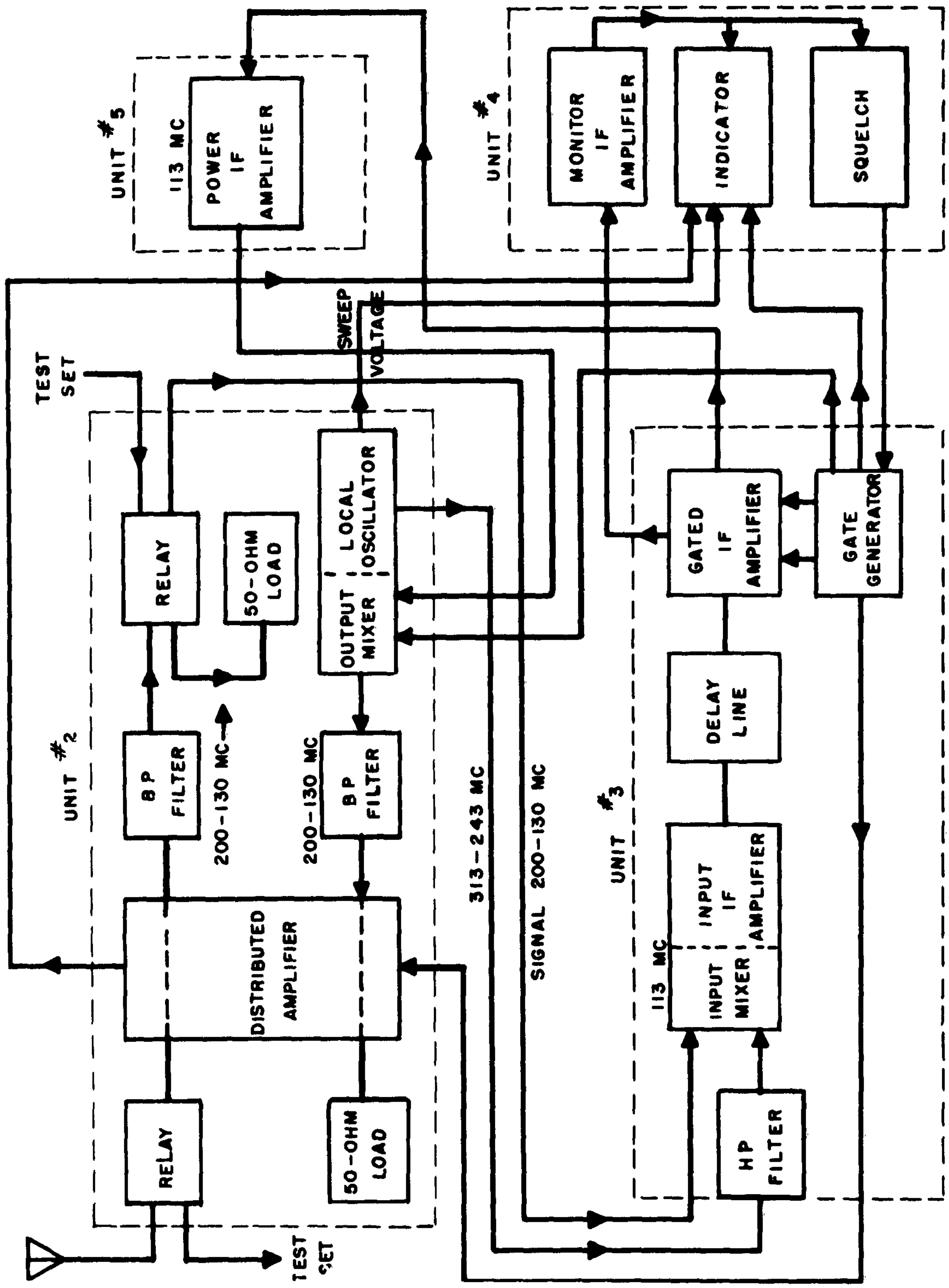

Fig. 33. Block diagram of the AN/MLQ-8(XL-2)

ANNEX D. BIBLIOGRAPHY

1. Instruction Manual Nr. EDL-B4, Electronic Countermeasures Set Type AN/MLQ-8(XL-1)(U). Electronic Defense Laboratory, Mountain View, Calif., 1 Sep 1955.

2. Technical Report Nr 55 Design of the AN/MLQ-8 Repeater Jammer (U), Engineering Research Institute, University of Michigan, Ann Arbor, Mich., Jan 1956.

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